YIL / YEAR | 2025

CİLT - SAYI / VOLUME - ISSUE | 33 / 02

e-ISSN | 2147-9844

KASTAMONU ÜNİVERSİTESİ KASTAMONU EĞİTİM DERGİSİ

KASTAMONU UNIVERSITY KASTAMONU EDUCATION JOURNAL

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Kastamonu Eğitim Dergisi

Yıl:2025 Cilt:33 No:2

Kastamonu Education Journal

Year: 2025 Volume: 33 Issue:2

Kastamonu Eğitim Dergisi Uluslararası Bilimsel Hakemli Dergidir.

Ocak-Nisan-Temmuz-Ekim Aylarında yılda 4 defa çevrimiçi olarak yayınlanır.

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Kastamonu Üniversitesi
Kastamonu Eğitim Dergisi

Kastamonu Education Journal, 2025, Vol. 33, No:2, 215-239
doi: 10.24106/kefdergi.1682910

| Research Article / Araştırma Makalesi|

Investigation of Seventh Grade Students' Written Mathematical Communication Skills

Yedinci Sınıf Öğrencilerinin Yazılı Matematiksel İletişim Becerilerinin İncelenmesi

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Keywords

1.Let's Tell intelligence game (LTIG)
2.Story
3.Written mathematical communication
4.Seventh-grade students

Anahtar Kelimeler

1.Haydi Anlat zekâ oyunu (HAZO)
2.Hikâye
3.Yazılı matematiksel iletişim becerisi
4.Yedinci sınıf öğrencileri

Received/Başvuru Tarihi
12.09.2023

Accepted / Kabul Tarihi
13.02.2025

Abstract

Purpose: The study aims to examine the written mathematical communication skills of seventh-grade students in the context of angles and lines in the stories they create in the Let's Tell Intelligence Game (LTIG).

Design/Methodology/Approach: According to the case study design, this study was conducted with 21 seventh-grade students at a secondary school in the Eastern Black Sea Region. The data of the study were collected by applying LTIG adapted to angles and lines and angles to the students. The stories created by seventh-grade students in the game ''Let's Tell a Story'' were analyzed concerning their written mathematical communication skills in the context of angles and lines. The stories created in LTIG were analyzed according to the mathematical concepts used, the identification of angles in the visuals, the correct and incorrect use of angles in the visuals, and the formal and informal expression of visual-angle examples, which were determined as written mathematical communication skill criteria.

Findings: As a result of the analyses, it was determined that the students had mostly intermediate level written mathematical communication skills, they used a small number of mathematical concepts in their stories and were able to determine only up to 33% of the angles in the visuals.

Highlights: It is recommended to use writing practices in mathematics lessons and to conduct them through storytelling.

Öz

Çalışmanın amacı: Amaç, yedinci sınıf öğrencilerinin, Haydi Anlat Zekâ oyunu'nda (HAZO) açılar ile doğrular ve açılar konuları bağlamında oluşturdukları hikâyelerdeki yazılı matematiksel iletişim becerilerini incelemektir.

Materyal ve Yöntem: Durum çalışmasına göre desenlenen bu araştırma, Doğu Karadeniz Bölgesinde bulunan bir ortaokulda öğrenim gören 21 yedinci sınıf öğrencisiyle gerçekleştirilmiştir. Araştırmanın verileri, açılar ile doğrular ve açılara uyarlanan HAZO'nun öğrencilere uygulanmasıyla toplanmıştır. HAZO'da oluşturulan hikâyeler yazılı matematiksel iletişim beceri kriterleri olarak belirlenmiş olan kullanılan matematik kavramları, görsellerdeki açıların belirlenmesi, görsellerdeki açıların doğru ve hatalı kullanım olma durumları ile görsel-açı örneklerinin formal ve informal ifade olma durumlarına göre analiz edilmiştir.

Bulgular: Yapılan analizlerin sonucunda, öğrencilerin çoğunlukla orta düzeyde yazılı matematiksel iletişim becerisine sahip oldukları, oluşturdukları hikâyelerde az sayıda matematik kavramına yer verdikleri ve görsellerdeki açıların en fazla %33'ünün belirlenebildiği tespit edilmiştir.

Önemli Vurgular: Matematik derslerinde yazma uygulamalarının kullanılması ve hikâyeler yoluyla gerçekleştirilmesi önerilmektedir.

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Citation/Alıntı: Hacısalihoğlu Karadeniz, M., & Hodancı, A.N. (2025). Yedinci Sınıf Öğrencilerinin Yazılı Matematiksel İletişim Becerilerinin İncelenmesi, *Kastamonu Education Journal, 33*(2), 215-239. doi: 10.24106/kefdergi.1682910

INTRODUCTION

Mathematical communication skill is defined as the ability to express mathematical thoughts verbally or in writing when explaining an algorithm, and to relate everyday language and symbols to mathematical language and symbols (Rajagukguk, 2016). In the same study, it was noted that this skill includes the ability to use different representation forms (concrete models, shapes, graphs, tables, symbols, etc.) when explaining relationships between concepts and mathematical ideas, as well as the awareness that mathematics is a communication tool with its unique symbols and language. For mathematical communication to take place meaningfully, the correct use of mathematical language, the understanding, interpretation, and creation of mathematical discourse (Chapin, O'Connor & Anderson, 2009; Sür & Delice, 2016) and the use of mathematical symbols and models (Sür & Delice, 2016) are largely important. Therefore, it can be said that there is a noticeable and important relationship between mathematical communication and mathematical language. A mathematical language is a communication tool that is formed by combining mathematical words with the language used in real life (Raiker, 2002; cited in Çakmak, 2013). According to Çalıkoğlu Bali (2003), mathematical language, unlike other languages, has the ability to express scientific ideas easily and is a collection of applications that contain mathematical concepts, operations, and symbols.

According to the Mathematics Curriculum (for Primary and Secondary Schools, Grades 1-8), published by the Ministry of National Education (MoNE) in 2018, students should be encouraged to engage in individual and interpersonal communication while sharing their methods of constructing mathematical concepts during the teaching process. In addition, in the previous curriculum (MoNE, 2009), it was stated that speaking, writing, and listening activities about mathematics not only improve communication skills but also provide opportunities for students to better understand mathematical concepts. The National Council of Teachers of Mathematics (NCTM) in the United States emphasizes the need for teachers to support students in their learning of mathematical concepts through the languages they bring to school, and to help them develop mathematical terms that facilitate better communication with each other. Therefore, teachers have a special responsibility to help their students learn to speak and write mathematically (Morgan, 2011).

According to Liebars (1997), writing in mathematics provides an opportunity for students to have a clear understanding of the concepts they know and do not know, give feedback, and slow down the thinking process to organize and reflect on their ideas. In addition, writing enables the teacher to "hear" the student and provides the teacher with information about students' schema, misconceptions, and thinking patterns related to concepts (Hoffman & Powell, 1989). These data about students contribute to their higher-order thinking and reasoning skills, provide them with an opportunity to think deeply and make writing an important part of classroom practices (King, Raposo & Gimenez, 2016). Similarly, studies on writing activities in mathematics classes have shown that they contribute to student achievement (Kasa, 2009; Yıldırım, 2016) and increase mathematical communication (Atasoy & Atasoy, 2006), exhibit problem-solving skills, and have a positive impact on student attitudes towards mathematics in an application (Küçük, 2019). Öztürk, Öztürk, and Işık (2016) also stated in their study that teachers believed that writing was a learning process for students and provided learning support. Therefore, it can be seen that the use of writing activities in mathematics classes provides many benefits to students. Some of the writing activities mentioned are expository writing, diary writing, writing a problem situation formed by a scenario, and giving students statements at the end of the lesson and writing their feelings and thoughts against these statements (Atasoy & Atasoy, 2006). Story writing can be considered as one of the writing activities that create an environment where students can apply these writing purposes.

A story is defined as a genre of text that usually describes real or possible events in a short form, typically involving time, place, and characters (Akçay & Akçay, 2017). Mathematical stories, on the other hand, are used as a way to overcome difficulties in understanding and applying mathematics, and to demonstrate the importance of mathematics by forming the basis of mathematical concepts (Franz & Pope, 2005). However, mathematical stories provide students with the opportunity to develop their skills in identifying questions and reasoning (Burton, 1985) and to discover the beauty of mathematics by experiencing new situations (Gadanidis & Hughes, 2011). In studies related to mathematical stories, it has been stated that these stories have a positive impact on learning (Franz & Pope, 2005), can be used to explain difficult mathematical concepts to students (Goral & Gnadinger, 2006), and can be used by students to relate their ideas about mathematics to real-life situations (Healy & Sinclair, 2007). Additionally, the problems created by students using story cards have been examined, and it has been noted that the results are believed to contribute to the teaching of mathematical concepts (Kaya & Ev-Çimen, 2021). The study on the use of story cards brought to mind an intelligent game played with the help of story cubes, and it was thought that students' written communication skills could be determined as well as their ability to write mathematical stories by playing this game.

In the Secondary School and Imam Hatip Secondary School Intelligence Games Course Curriculum, it is stated that intelligence games are a powerful communication tool and provide the opportunity to communicate with people from all over the world as a universal indicator of knowledge and experience (MoNE, 2013). In this program, intelligence games are defined as a gamified version of all kinds of problems, including real problems, and are discussed in terms of creating different perspectives, developing the habit of focusing on a subject and solution, and developing the skills of reasoning and using logic effectively. The games in the program are handled at three levels: “Beginner Level-D1”, “Intermediate Level-D2”, and “Advanced Level-D3”. In addition, the games in the program are classified into six categories: “Reasoning and Operation Games”, “Verbal Games”, “Geometric-Mechanical Games”, “Memory Games”, “Strategy Games”, and “Intelligence Questions”. Verbal games, one of the categories of intelligence games, are defined as types of games in which players make use of their vocabulary or general culture as well as their

logical inferences, and it is stated that the games can be one-person or team games. In addition, in the aforementioned curriculum, the D1 level of verbal games includes comprehending the basic rules and using words from different fields in games; the D2 level includes deriving appropriate words for the game by using vocabulary and determining basic strategies specific to verbal games; and the D3 level includes reducing the list to be searched by making smart guesses and finding the best solutions in verbal games within the given constraints.

In this context, Let's Tell Intelligence Game (LTIG), which was used in the current study, is in the category of verbal games since it is a game that requires players to create stories by utilizing their existing vocabulary (MoNE, 2013) and is one of the intermediate level intelligence games.

The reasons for preferring this game in the study are that it enables students to create stories during the game process in order to reveal their written mathematical communication skills, it is an easy game, and it is a game that students generally know and like. In studies related to intelligence games, basic geometric concepts and drawings, triangles and quadrilaterals, length and time measurement, data collection and evaluation (Aslan, 2022), patterns and spatial relationships (Esen, 2021), integers, operations with integers, algebraic expressions and area measurement (Demirel, 2015), operations with natural numbers, operations with integers, sets and area measurement (Şanlıdağ, 2020) have been addressed. Therefore, it can be observed that the topics of "Angles" and "Lines and Angles" were not covered in these studies. The adaptation of LTIG in this study focuses on the sub-learning areas of "discovers the properties of adjacent angles, complements, supplements, and vertical angles; solves related problems" and "determines the properties of corresponding, alternate, interior, and exterior angles formed by two parallel lines intersected by a transversal; determines which angles are congruent or supplementary; solves related problems." These learning outcomes were chosen because LTIG includes visuals that are relevant to real-life situations and various angle types. Therefore, the aim is to examine the understanding of the concepts included in these outcomes such as adjacent angles, complementary angles, supplementary angles, vertical angles, corresponding angles, alternate angles, interior angles, and exterior angles.

On the other hand, when the literature is reviewed, no study has been found that examines students' written mathematical communication skills through an intelligence game adapted to mathematics. The current study is important in demonstrating that the verbal intelligence game LTIG can be adapted to mathematics, examining students' written mathematical communication skills through LTIG, and presenting the possibility of using intelligence games with stories in mathematics classes. In this context, the study aims to examine the written mathematical communication skills of seventh-grade students in the stories they create in the context of "Angles" and "Lines and Angles" in LTIG. Therefore, the basic problem of the study can be expressed as follows:

"What are the written mathematical communication skills of seventh-grade students in the stories they create in LTIG?"

METHOD/MATERIALS

The study used a case study design as a qualitative research method. A case study is a research method that focuses on the "how" and "why" questions, and where the researcher has little or no control over the events and the phenomenon is examined in its natural setting (Yıldırım & Şimşek, 2016; Yin, 1984). Additionally, in a case study, a well-defined research topic is described and examined in detail in its real environment (Birinci, Kılıçer, Ünlüer & Kabakçı, 2009). The term "boundary" in this context refers to the ability of the situation to be distinguished from others in terms of time, place, or some physical boundaries (Creswell, 2012). Therefore, the reason why this research is a case study is to provide a rich understanding by examining how seventh grade students' written mathematical communication skills in the stories they created in LTIG, without aiming to generalize.

Sample of the Research

This study consisted of 21 (12 female, 9 male) seventh-grade students who were enrolled in a middle school located in the Eastern Black Sea Region. Criterion sampling, one of the purposive sampling methods, was used to select the participants. The basic understanding of this sampling method is to obtain all cases that meet a predetermined set of criteria. The criteria can be created by researchers or predetermined forms can be used (Teddlie & Yu, 2007; Yıldırım & Şimşek, 2016). In this study, the criteria used to select the participants were being seventh-grade students and having completed classroom activities related to the sub-learning areas of "Angles" and "Lines and Angles". The names of the participating students were kept confidential, and they were coded as "S1, S2, S3, ... S21".

Data Collection Tool

In this study, the LTIG game material prepared by adapting the concepts of “Angles” and “Lines and Angles” was used as a data collection tool. The original LTIG game and its adaptation to the related concepts are explained below.

Let’s Tell Intelligence Game

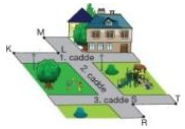
LTIG is a verbal game played with 12 specially printed wooden cubes. In the game, the cubes are thrown onto a surface randomly. Then, these cubes are arranged in a certain order. The person playing the game tells a story based on the shapes seen on the cube (https://www.redka.com.tr/redka-haydi-anlat.html). The LTIG image is given below.

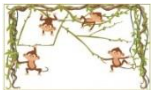
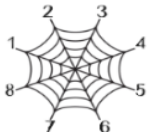
Figure 1. Original LTIG

Let's Tell Intelligence Game Adapted to Angles and Lines with Angles Topics

In order to adapt LTIG to the relevant mathematical concepts, first, 30 different visuals with real-life angle examples were identified. In the curriculum, sixth-grade students are expected to discover the properties of adjacent, complementary, supplementary, and vertical angles, and to solve related problems; while seventh-grade students are expected to identify corresponding, alternate, interior, and exterior angles formed by two parallel lines and a transversal, and to examine their properties, and to find those that are equal or supplementary (MoNE, 2018). In this context, the visuals selected for LTIG were chosen in a way that could reveal these concepts related to angles. The visuals used in the game were coded as I1, I2, ..., and I30. In order to ensure the validity of the visuals selected to be used in LTIG, the opinions of two field experts and a mathematics teacher were consulted, and the visuals were examined by taking into consideration whether they were examples of Angles and Lines and Angles and whether they were suitable for associating with daily life. In line with the expert opinions, these visuals were removed because there were few examples of angles in 4 visuals and it was thought that students would have difficulty in associating the objects or situations in the visuals with daily life. In addition, based on expert opinions, 4 visuals were added instead of these visuals, in which angle examples were seen more clearly, angle examples were more numerous, and it was thought that they could be associated with daily life more easily. These visuals and the types of angles that students are expected to identify in the visuals are given in Table 1.

Table 1. Images used in the game and the types of angles to be identified in each image

Images	Types of Angles in the Images	Images	Types of Angles in the Images	Images	Types of Angles in the Images
I1. Ferris Wheel 	Reverse angle, acute angle, straight angle, right angle.	I2. Scissors 	Inverse angle, acute angle, obtuse angle, complementary angle.	I3.Sketch Example 	Corresponding angles, acute angle, right angle, interior alternate angle.
I4. Bicycle 	Acute angle, straight angle, obtuse angle, interior angle, exterior angle, supplementary angle.	I5. Example of a sports branch 	Right angle, acute angle, straight angle.	I6. Pages 	Acute angle.
I7. Clock 	Acute angle, straight angle, supplementary angle, vertical angle, obtuse angle.	I8. Window 	Vertical angle, acute angle.	I9. A circus performance 	Acute angle, straight angle, right angle, obtuse angle.
I10. Desk 	Acute angle, vertical angle, corresponding angle, interior alternate angles, exterior angle, obtuse angle.	I11. Mancala Games 	Obtuse angle, acute angle, vertical angle.	I12. Hanger 	Acute angle, right angle, interior alternate angles, supplementary angle, exterior angle, corresponding angles.
I13. Glasses 	Obtuse angle, acute angle, vertical angle	I14. Fan 	Straight angle, acute angle, obtuse angle, supplementary angle	I15. Ship Origami 	Obtuse angle, acute angle, right angle

I16. Chair 	Vertical angle, acute angle	I17. Ironing Board 	Acute angle, vertical angle, reverse angle, straight angle, obtuse angle	I18. Revolving Door 	Acute angle, reverse angle, obtuse angle, right angle
I19. Car 	Acute angle, right angle, obtuse angle, adjacent angles	I20. Hanging monkeys 	Acute angle, right angle, Obtuse angle, complementary angle	I21. Spiderweb 	Straight angle, acute angle, right angle, reverse angle, alternate interior angle
I22. Goose 	Acute angle, Right angle	I23. Kite 	Right angle, Acute angle, Obtuse angle, obtuse angle, interior angle.	I24. Playground 	Reverse angle, acute angle, right angle, alternate interior angle, corresponding angle, obtuse angle
I25. Garden Chair 	Acute angle, right angle,obtuse angle, interior angle açı, complementary angles	I26.Football Players 	Obtuse angle, Acute angle, right angle	I27. Plane 	Obtuse angle, acute angle, right angle.
I28.Runner 	Right angle, Acute angle	I29. Ice skate 	Acute angle, right angle, obtuse angle	I30. Flamingo 	Right angle, acute angle, reverse angle, supplementary angle, obtuse angle, interior angle, complementary angle

In the second step of the adaptation process of LTIG to mathematics, cubes were made using cardboard in five different colors. The game materials were prepared by pasting the visuals selected from Table 1 on the faces of the cubes and are given in Figure 2.

Figure 2. LTIG material adapted to angles and lines.

The Data Collection and Implementation Process

LTIG was administered to the students in 2 class hours (80 minutes) with the participation of one of the researchers. During this implementation process, the original LTIG was first introduced to the students. Then, the adapted game application was started and the students were asked to take turns on the board and throw the game cubes on an empty table once. When the students threw the game cubes, a 5 cm x 5 cm printout of the image that appeared on the top of the cube was given to the student. In this way, it was ensured that the students did not forget the visuals they obtained while creating the stories. Therefore, each student obtained a total of five images. The visuals used by the students while writing stories in LTIG are given in Table 2.

Table 2. Visuals used by students in LTIG

Participants	Used Visuals
S_1	Clock (G7), Car (G19), Kite (G23), Runner (G28), Ice Skating (G29)
S_2	Glasses (G13), Ironing Board (G17), Car (G19), Spider Web (G21), Runner (G28)
S_3	Carousel (G1), Window (G8), Origami Ship (G15), Chair (G16), Kite (G23)
S_4	Sketch Example (G3), Bicycle (G4), Clock (G7), Garden Chair (G25), Flamingo (G30)
S_5	Circus Show Example (G9), Hanger (G12), Glasses (G13), Children's Playground (G24), Football Players (G26)
S_6	Scissors (G2), Bicycle (G4), Children's Playground (G24), Garden Chair (G25), Runner (G28)
S_7	Sketch Example (G3), Row (G10), Mancala Game (G11), Goose (G22), Football Players (G26)
S_8	Glasses (G13), Origami Ship (G15), Ironing Board (G17), Car (G19), Spider Web (G21)
S9	Book Pages (G6), Glasses (G13), Ironing Board (G17), Spider Web (G21), Flamingo (G30)
S10	Sports Branch Example (G5), Fan (G14), Ironing Board (G17), Revolving Door (G18), Children's Playground (G24)
S11	Chair (G16), Ironing Board (G17), Revolving Door (G18), Car (G19), Kite (G23)
S12	Mancala Game (G11), Glasses (G13), Car (G19), Monkey Bars (G20), Goose (G22)
S13	Sketch Example (G3), Sports Branch Example (G5), Circus Show Example (G9), Football Players (G26), Flamingo (G30)
S14	Sketch Example (G3), Desk (G10), Mancala Game (G11), Fan (G14), Monkey Bars (G20)

S15	Sketch Example (G3), Sports Branch Example (G5), Circus Show Example (G9), Hanger (G12), Garden Chair (G25)
S16	Glasses (G13), Fan (G14), Origami Ship (G15), Ironing Board (G17), Ice Skating (G29)
S17	Bicycle (G4), Clock (G7), Children's Playground (G24), Football Players (G26), Runner (G28)
S18	Scissors (G2), Bicycle (G4), Goose (G22), Garden Chair (G25), Flamingo (G30)
S19	Sports Branch Example (G5), Chair (G16), Monkey Bars (G20), Football Players (G26), Flamingo (G30)
S20	Bicycle (G4), Origami Ship (G15), Car (G19), Kite (G23), Children's Playground (G24)
S21	Book Pages (G6), Circus Show Example (G9), Revolving Door (G18), Children's Playground (G24), Garden Chair (G25)

Data Analysis

LTIG, which was prepared to collect the data of the study, was applied to 21 students and each of them was asked to write a story. It was decided to evaluate the stories written by the students according to the following four criteria in the context of expert opinion:

The stories written by the students were evaluated according to the following four criteria:

1. Mathematics concepts used in the story
2. Identification of angles in the visuals used in the story
3. Whether the angle examples used in the story are correct or incorrect
4. Whether the visual-angle examples used in the story are formal or informal expressions

The stories obtained in the study were analyzed independently by the researchers according to the relevant criteria. In the analyses, the researchers analyzed the participants' stories in the context of the criteria given above. In the second step, the researchers came together and compared their analyses and decided on the final version of the analysis after eliminating the differences between the analyses.

Mathematics concepts used in the story:

With this criterion, it was attempted to determine how many different concepts the students used when explaining an event in their story. The different concepts used while reading the story (acute angle, right angle, obtuse angle, straight angle, reflex angle, complete angle, supplementary angle, complementary angle, adjacent angle) were underlined, and the concept count was determined by counting them. However, when determining the concept counts, only the concepts used for angles and lines were taken into account, and concepts used for all topics of mathematics were considered. In addition, if the same concept was used repeatedly, it was not taken into account.

Determining angles in the used visuals in the story:

The second evaluation criterion is the determination of angles in the visuals used by the students in each story. Firstly, the total number of angle types in the visuals used by the students while writing their stories was calculated using Table 1 and presented in Table 2. Then, the angles used in the stories were determined, and their ratios were examined based on the total number of angle types, and the percentage values for angle determination were calculated (Table 5).

The correct and incorrect use of angle examples in the story:

With this criterion, sentences in which students described angles in any visual and expressed them in relation to the relevant parts of the visuals were evaluated as correct or incorrect. Sentences in which angle examples related to visuals were identified in the story were underlined and evaluated separately. For example, sentences such as "My game on a wide-angle barbecue" and "We saw flamingos with right angles on their legs" were coded as correct visual-angle examples. However, students who mentioned angle examples that were not present in the visuals were evaluated as incorrect visual-angle examples, such as "The stem of the glasses is an example of the u-rule or complementary angle." In this context, the analyses were classified according to the mathematical communication skills assessment rubric developed by Wahyuningrum and Suryadi (2014), which was modified by the researchers. In the original rubric, student performances were divided into five and scored as "0, 1, 2, 3, 4." In this study, four of these performances were used, category names were assigned to the performances, and

the relevant rubric is presented in Table 3. When determining the levels based on the number of correct and incorrect visual-angle examples used in the students' stories, the equation "the width of the series is divided by the desired number of groups (Tekin, 2007)" was taken into account.

Table 3. Rubric for assessing mathematical written communication skills in the context of the "visual-angle" example

Category	Written Mathematical Communication Skill
Incorrect or insufficient narrative (0)	All of the "visual-angle" examples provided by the student are incorrect or no concept is included.
Low-level communication (1)	The use of mathematical language (terms, symbols, signs or representations) is partially correct.
Medium-level communication (2)	Use of mathematical language (terms, symbols, signs, or representations) is correct and detailed.
High-level communication (3)	Use of mathematical language (terms, symbols, signs, or representations) is correct and highly detailed.

Formal and informal expressions of the visual-angle examples used in the narrative:

With this criterion, it was examined whether the descriptions of angles in the sentences explaining the angle examples in the visuals were made by paying attention to the basic properties of these concepts and whether the expressions were formal or informal. Therefore, the student's knowledge of the basic properties of the angle examples used in the narrative was analyzed. For example, the statement "the fan made a right angle of 180°." was considered as a formal expression since the basic features of the concept were taken into account in the visual-angle example, such as the right angle being 180°. On the other hand, the statement "one day the monkeys were sitting on vines with counterfactual angles." was considered as an informal expression of the visual-angle examples since the concept of counterfactual angle does not make sense in the context of the Angles topic.

Validity and Reliability of the Study

In order to ensure the quality of a qualitative study, it should possess credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). In this context, credibility and consistency in the study were ensured by analyzing the data separately by the researchers and analyzing them four times in total, with one week between the analyses. In this context, the researchers worked on examining the stories written by the students according to the criteria specified in the analysis. As mentioned, during these studies, which were carried out at different times with a one-week interval, the classifications made for the students' stories were compared with each other, the similarities and differences between these classifications were examined and revised again in the context of expert opinions. In this way, the quality of the current study was attempted to be improved. Confirmability of the study was attempted to be ensured by including as many stories as possible written by the 7th-grade students at LTIG during the presentation of the research. Transferability was attempted to be achieved by describing and interpreting the study in a clear and detailed manner. Within this scope, the mathematical concepts used in the stories by the students, angle examples in the visuals used in the stories, the percentages of the determination of these examples, and whether they were in formal or informal expressions were classified, organized, interpreted, and presented with example stories in the findings section. Additionally, the sampling method used to select the students included in the study was explained in detail to ensure the transferability of the study.

FINDINGS

This section provides examples of mathematical concepts and numbers, percentages for determining angles in visuals, correct and incorrect use of angle examples in visuals, as well as formal and informal expressions of the numbers and visual-angle examples used in the stories created by participants in the LTIG.

The findings related to mathematical concepts used in the story

The concepts were identified by examining the expressions used by seventh-grade students while creating their stories in LTIG and presented in Table 4.

Table 4. Mathematical concepts and numbers used in the story

Participants	Mathematics Concepts in the Story Created in LTIG	Number of Mathematics Concepts in the Story Created in LTIG
S_1	Right angle, obtuse angle, 360 degrees.	3
S_2	Diameter, vertex, area, triangle, trapezoid, square, isosceles triangle, interior opposite angle, right angle, 120 degrees	10
S_3	Circle, hexagon, rectangle, vertex, equilateral triangle, right triangle, straight angle, interior angle, supplementary angle, corresponding angle.	10
S_4	Interior opposite angle, supplementary angle, exterior opposite angle, co-interior angle, obtuse angle, right angle, corresponding angle.	7
S_5	Acute angle, right angle, obtuse angle.	3
S_6	Right angle, complementary angle, co-interior angle, supplementary angle, obtuse angle.	5
S_7	Obtuse angle, acute angle, right angle.	3
S_8	Interior opposite angle, corresponding angle.	2
S_9	Right angle, adjacent supplementary angle, straight angle, obtuse angle, acute angle, circle, corresponding angle, 5 minutes.	8
S_{10}	Acute angle, obtuse angle, 150 degrees.	3
S_{11}	Supplementary angle, interior opposite angle, acute angle, corresponding angle.	4
S_{12}	Obtuse angle, acute angle, right angle, corresponding angle.	4
S_{13}	Supplementary angle, obtuse angle, co-interior angle, interior opposite angle, exterior opposite angle, right angle, straight angle, 20 seconds.	8
S_{14}	Right angle, straight angle, obtuse angle, acute angle.	4
S_{15}	Co-interior angle, supplementary angle, acute angle, obtuse angle, interior opposite angle, exterior opposite angle, 2 days, 180 degrees.	8
S_{16}	Acute angle, obtuse angle, supplementary angle, opposite angle, corresponding angle.	5
S_{17}	Acute angle, complementary angle, right angle, 2 months, 30 seconds, 2 meters.	6
S_{18}	Acute angle, right angle, obtuse angle, interior opposite angle, supplementary angle, 2 days.	6
S_{19}	Acute angle, right angle, complementary angle, obtuse angle, supplementary angle, parallel, Z rule (interior opposite angle rule).	7
S_{20}	Right angle, equilateral triangle, square, trapezoid, circle, hexagon, 360 degrees.	7
S_{21}	Acute angle, right angle, obtuse angle.	3

When Table 4 is examined, it is seen that in the stories written by the students in LTIG, S8 included at least 2 concepts, namely, internal inverse angle and counterfactual angle; S2 included at most 10 concepts, namely, diameter, corner, area, triangle, trapezoid, trapezoid, square, isosceles triangle, internal inverse angle, right angle, 120 degrees; and S3 included at most 10 concepts, namely, circle, hexagon, rectangle, corner, equilateral triangle, right triangle, acute angle, interior angle, integral angle, counterfactual angle. However, it is seen that the concepts used by the students are not limited to the topics of angles and lines and angles, and that there are also concepts related to the topics of Circle and Circle, Triangles and Quadrilaterals and Time Measurement in the stories.

Findings Related to Determining the Angles in Visuals Used in the Story

Table 5 provides the percentage values for determining the angles in the visuals used by the students while writing stories.

Table 5. Percentage values of students for determining angles in visuals

Participants	Percentage Values	Participants	Percentage Values
S_1	%11	S_{12}	%24
S_2	%11	S_{13}	%33
S_3	%25	S_{14}	%18
S_4	%25	S_{15}	%27
S_5	%14	S_{16}	%28
S_6	%21	S_{17}	%13
S_7	%17	S_{18}	%20
S_8	%10	S_{19}	%30
S_9	%29	S_{20}	%4
S_{10}	%9	S_{21}	%15
S_{11}	%20		

When examining Table 5, it can be seen that S13 identified the highest number of angle types by determining 33% of the angles used in the visuals they used in their story, while S20 discovered the least number of angle types by identifying only 4% of the angles in the visuals.

The Findings on Examples of Correct and Incorrect Use of Angles in Visuals Used in the Story

The 21 stories written by the students in LTIG were analyzed with the help of the evaluation rubric given in Table 3. The written communication levels of the statements specified for each criterion are given in Table 6.

Table 6. The number of correct and incorrect use of angle examples in the visuals used in the story and the level of written communication

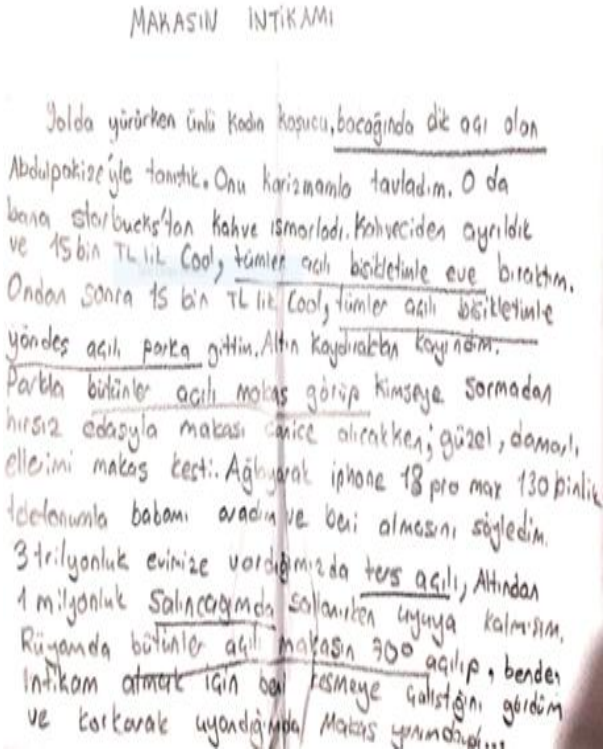
Participants	Correct Usage Examples of Angle Illustrations Used in the Story	Incorrect Usage Examples of Angle Illustrations Used in the Story	Written Communication Level
S_1	Runner (right angle), ice skating (obtuse angle)	-	Intermediate level communication
S_2	Spider web (alternate interior angle), runner (right angle), car (right angle)	-	Intermediate level communication
S_3	Ship origami (right angle), window (right angle)	Ferris wheel (full angle), chair (opposite angles), kite (complementary angles)	Low-level communication

S_4	Garden chair (obtuse angle), clock (obtuse angle/straight angle/right angle), bicycle (exterior angle), sketch (corresponding angle), flamingo (obtuse angle/vertical angle)	Flamingo (opposite angles)	High-level communication
S_5	Glasses (acute angle), circus performance (right angle), soccer players (wide angle)	-	Intermediate level communication
S_6	Runner (right angle), children's playground (corresponding angle), garden chair (obtuse angle), scissors (complementary angle), bicycle (vertical angle)	-	High-level communication
S_7	Mancala (acute angle/wide angle), goose (acute angle), sketch (right angle/acute angle), soccer players (wide angle)	-	High-level communication
S_8	Spider web (interior angle)	Glasses (corresponding angles), car (corresponding angles), origami ship (corresponding angles), ironing board (corresponding angles)	Low-level communication
S_9	Flamingo (right angle), spider web (acute angle), ironing board (right angle/wide angle/acute angle)	Glasses (U rule), book pages (adjacent supplementary angles), ironing board (Z rule)	Intermediate level communication
S_{10}	Fan (acute angle), children's playground (wide angle)	-	Intermediate level communication
S_{11}	Revolving door (obtuse angle), kite (obtuse angle), chair (acute angle)	Car (opposite angles), ironing board (opposite angles)	Intermediate level communication
S_{12}	Mancala (wide angle), goose (acute angle), glasses (wide angle), car (right angle)	Monkey bars (corresponding angles),	Intermediate level communication
S_{13}	Flamingo (obtuse angle), circus performance (wide angle), soccer players (right angle), sketch (corresponding angles)	Sketch (external alternate angles)	Intermediate level communication
S_{14}	Desk (right angle), fan (acute angle), sketch (obtuse angle), monkey bars (right angle/acute angle/obtuse angle), mancala (obtuse angle)	Sketching (right angle/wide angle)	High-level communication
S_{15}	Sketch (adjacent angles), garden chair (acute angle), hanger (acute angle), circus show (acute angle/obtuse angle)	Examples of a sports branch (reflex angle), hanger (obtuse angle), circus show (interior alternate angle/exterior alternate angle/corresponding angle)	Low-level communication
S_{16}	Glasses (acute angle), ice skating (acute angle), ship origami (obtuse angle), fan (complementary angle), ironing board (obtuse angle	Glasses (vertical angles)	Intermediate level communication
S_{17}	Children's playground (acute angle), bicycle (acute angle), clock (multiple	-	High-level communication

	angles), soccer players (right angle), runner (acute angle)		
S_{18}	Goose (acute/right angle), flamingo (right angle), garden chair (obtuse angle), bicycle (acute angle), scissors (straight angle)	Scissors (alternate interior angle)	High-level communication
S_{19}	Monkey bars (acute/obtuse/straight angle), flamingo (right angle), soccer players (right/obtuse angle)	Monkey bars (parallel angles), chair (Z rule/wide angle), an example of sports branch (supplementary angles/wide angle)	Low-level communication
S_{20}	-	-	Wrong or insufficient story
S_{21}	Book pages (acute angle), circus performance (acute angle), garden chair (right angle), revolving door (obtuse angle)	-	Intermediate level communication

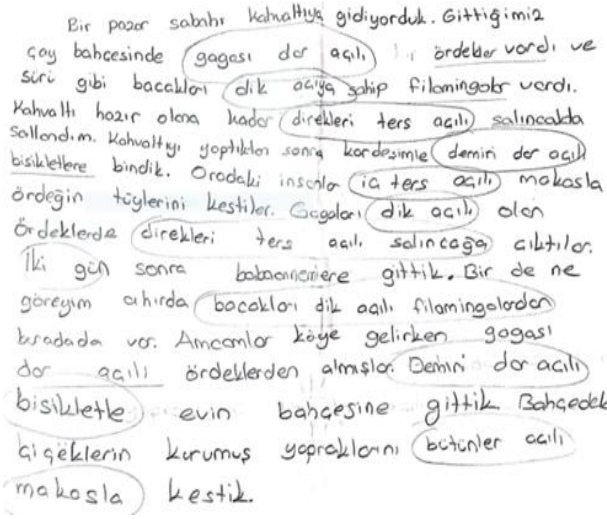
When Table 6 is examined, when the stories written by the students in LTIG are classified according to the number of correct and incorrect angle examples in the visuals, it is seen that they mostly exhibited a moderate level of mathematical communication (n=10), and only one student's written communication level was insufficient because he did not include any visual-angle examples in his story. However, 6 students had high level written communication skills and 4 students had low level written communication skills.

The stories in LTIG that contain examples of visual angles are provided as high-level communication (Figure 3), moderate-level communication (Figure 4), low-level communication (Figure 5), and incorrect or inadequate responses (Figure 6) examples below.



THE REVENGE OF THE SCISSORS

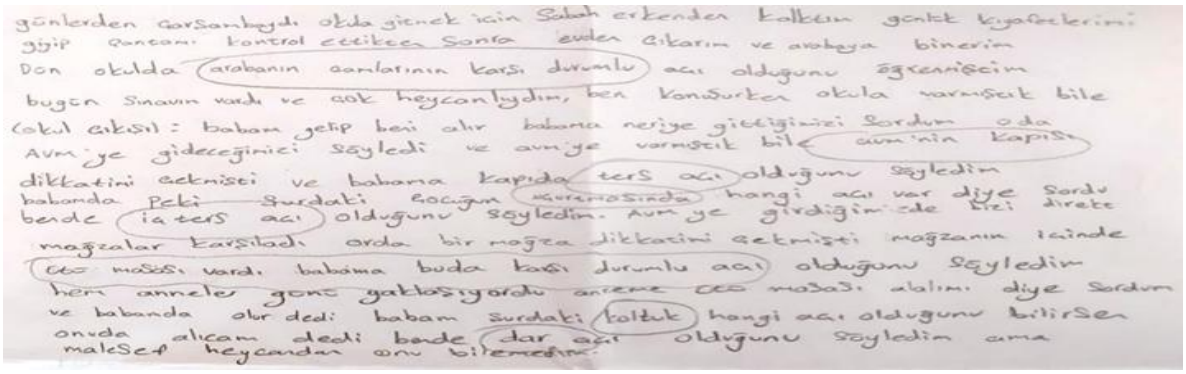
While walking on the street, I met a famous female runner named Abdulpakize, who had a right angle on her leg. I charmed her with my charisma and she bought me coffee from Starbucks. We left the coffee shop and I went to the corresponding angle park on my expensive bike with complementary angles, worth 15,000 TL. I slid down the golden slide. When I saw supplementary angle scissors in the park, I acted like a thief and tried to take them without asking anyone. However, the scissors cut my beautiful, veiny hands. I cried and called my father with my iPhone 18 Pro Max, which costs 130,000 lira, asking him to pick me up. When we arrived at our house, which costs 3 trillion lira, I fell asleep while swinging on my 1 million lira golden swing with reverse angles. In my dream, I saw the complementary angle scissors trying to cut honey at a 70-degree angle to take revenge on me, and when I woke up in fear, the scissors were next to me...



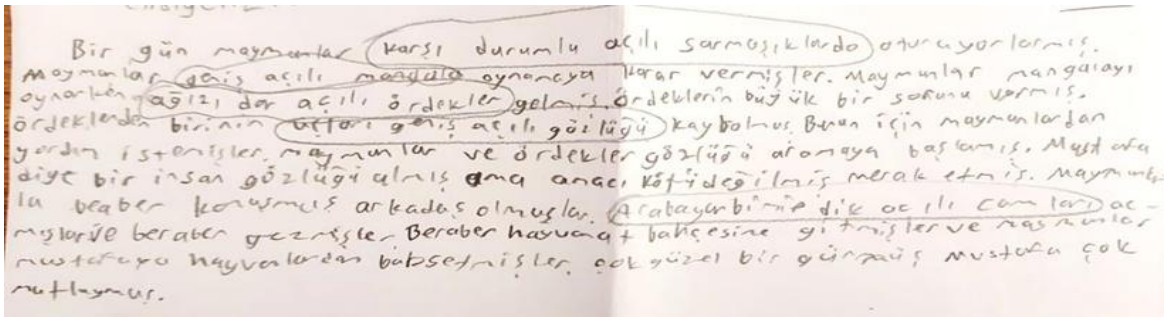
One Sunday morning, we set out for breakfast. There were ducks with acute-angled beaks and flamingos with legs at right angles in the tea garden where we went. While waiting for breakfast to be ready, I swung on a swing with reverse-angle hanging ropes. After breakfast, my brother and I rode on our iron bicycles with acute angles. The people there cut the feathers of the duck with an interior angle. The ducks with right-angled beaks climbed onto the reversed-angled swing. Two days later, we went to my grandmother's house and I saw that there were also flamingos with right-angled legs in the barn. My uncle had bought the ducks with acute-angled beaks when they came to the village. We went to the house on an acute-angled iron bicycle. We used supplement-angled scissors to cut the dried leaves of the flowers in the garden.

Figure 3. **Examples of high-level communication (S6 and S18)**

The student coded S18, whose written explanation is given in Figure 3, correctly identified 6 out of 7 visual-angle examples in the visuals he used while writing the story, and the student coded S6 correctly identified all 5 visual-angle examples in the visuals he used while writing the story. From this point of view, it was seen that the terms used in the stories about the use of mathematical language were correct and detailed by explaining them with angle examples. Therefore, it is seen that T6 and T18 exhibited a high level of mathematical communication by including correct and highly detailed expressions in the use of mathematical language.



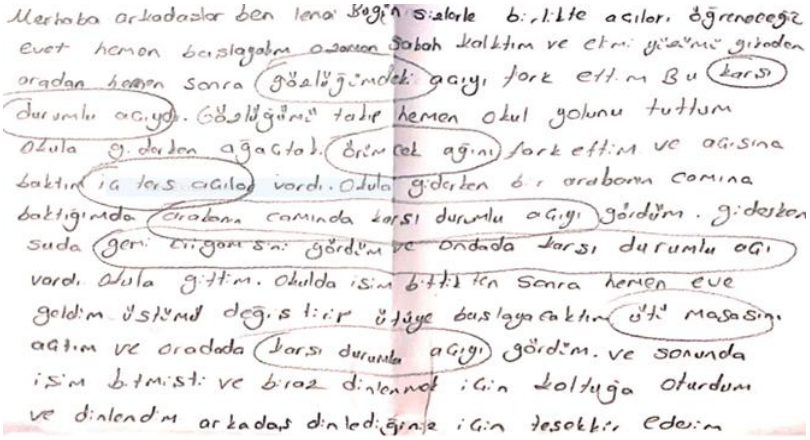
It was Wednesday and I woke up early in the morning to go to school. After putting on my daily clothes and checking my bag, I left the house and got into the car. Yesterday, I learned that the windows in the car were in vertical angles while I was at school. Today, I was very excited because I had an exam. We arrived at school while I was talking. After school, my dad came to pick me up and I asked him where we were going. He said we were going to the shopping mall and we had already arrived, I noticed that the door of the mall was in reverse position. I told my dad that the door was in the reverse position. Then he asked me, "What about the angle of the kite that boy is flying over there?" I said it was an alternate interior angle. When we entered the shopping mall, we saw the stores. One store caught my attention, it had an ironing board inside, so I told my dad that the ironing board had vertical angles of the legs. Since Mother's Day was approaching, I asked my dad if we should buy an ironing board for my mom. He agreed and said, "If you can tell me the angle of that chair over there, I will buy it too." I said it was an acute angle, but unfortunately, due to excitement, I couldn't remember it accurately.



One day, the monkeys were sitting on vines that had a vertical angles. The monkeys decided to play a wide-angled game of Mangala. While the monkeys were playing Mangala, ducks with acute-angled beaks came along. The ducks had a big problem; one of them had lost their obtuse-angled glasses. So, they asked the monkeys for help. The monkeys and ducks started to search for the glasses. A human named Mustafa got glasses, but his intentions were not bad, he was just curious. Mustafa became friends with the monkeys. They got into the car and opened the right angled windows, and drove around together. They went to the zoo and the monkeys told Mustafa about the animals. It was a beautiful day, and Mustafa was very happy.

Figure 4. Examples of intermediate-level communication (S11 and S12)

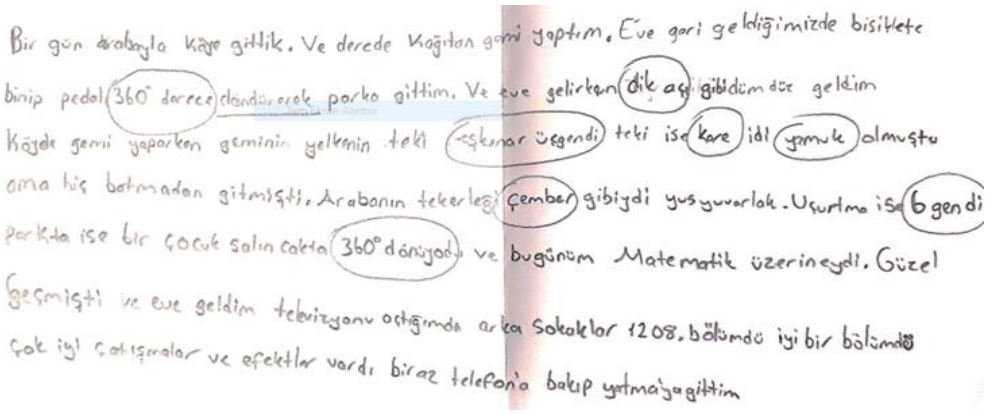
S11 coded student, explained in Figure 4, correctly identified 3 out of 5 visual-angle examples used in their story, while S12 coded student correctly identified 4 out of 5 visual-angle examples used in their story. Therefore, it is seen that they exhibited a moderate level of mathematical communication by including mostly correct and detailed statements in the use of mathematical language.



Hello friends, I'm Lena. Today we are going to learn about angles together. Yes, let's start right away then! I woke up in the morning and washed my face, and while putting on my glasses, I noticed the angle in my glasses. It was a vertical angle. I put on my glasses and set off to school immediately. On the way to school, I noticed a spider web on a tree and looked at its angles. There were interior angles. When I looked at a car window while going to school, I saw the vertical angle in the car window. While on the way, I saw a paper boat in the water, and it also had a vertical angle. I arrived at school. After finishing my work at school, I quickly came home. I changed my clothes and was about to start ironing. I noticed the vertical angle on the ironing board. Finally, my work was done, and I sat down on the couch to rest. Thank you for listening.

Figure 5. An example of low-level communication (S8)

The student with the code S8, described in Figure 5, incorrectly identified all 5 visual-angle examples in the images used in their story. Therefore, in the story written by S8, it is seen that the terms, symbols, signs or representations related to the use of mathematical language are incorrect and the student exhibits a low level of written mathematical communication.



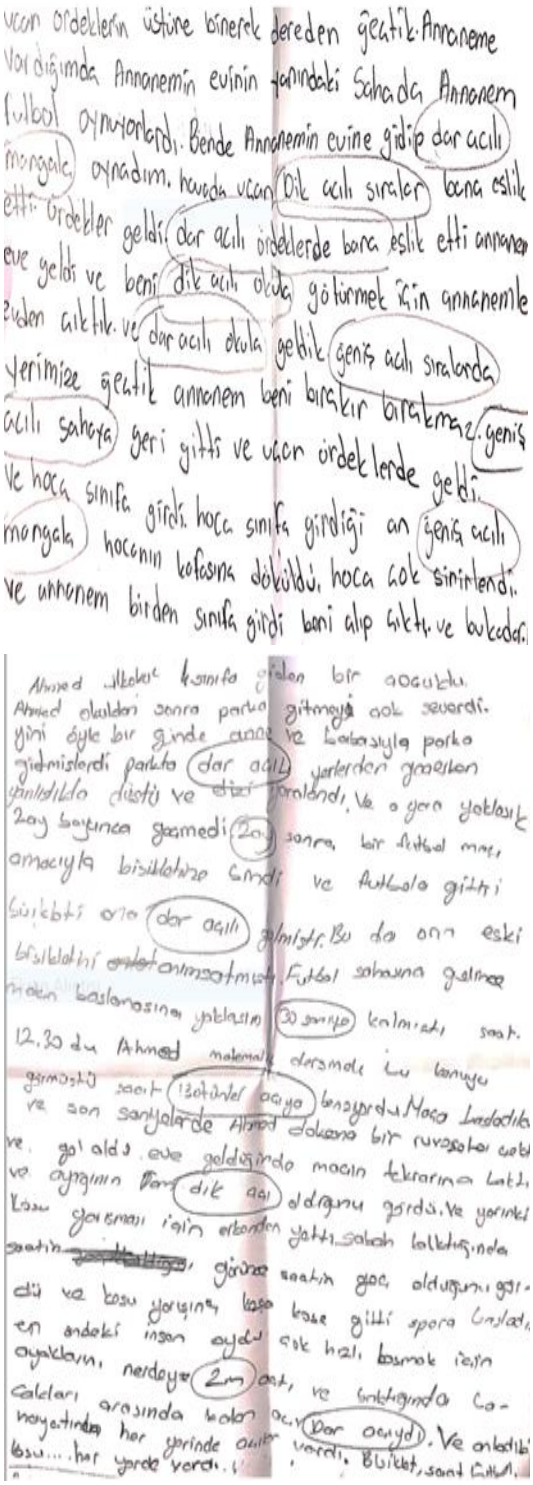
One day, we went to the village by car. I made a paper boat in the creek. When we got back home, I rode my bike and went to the park by pedaling 360 degrees. And when I came back home, I came straight as a right angle. While making the boat in the village, one sail was an equilateral triangle and the other was square but then it was a trapezium, yet it managed to sail without sinking. The wheel of the car was like a circle. The kite was hexagonal and there was a child swinging 360 degrees in the park, and today everything was about math. It was a nice day and when I turned on the TV, it was the 1208th episode of "Arka Sokaklar". It was a good episode with great action scenes and effects. After checking my phone for a while, I went to bed.

Figure 6. An example of a wrong or insufficient answer (S20)

As explained in Figure 6, the student with the code S20 was unable to correctly identify any of the angle examples used in their story. Therefore, since all of S20's angle examples are incorrect and the concepts related to angles are not used correctly, this story is considered incorrect or insufficient in terms of mathematical communication and is not included at any level of mathematical communication.

The Findings on the Formal and Informal Expressions of the Visual-Angle Examples Used in the Story

It has been observed that there are correct and incorrect uses in identifying angle examples in the visuals of the stories written by the students in LTIG, and therefore, formal and informal expressions related to angle concepts are included. In the formal definition, the properties of the terms are taken into consideration in the expressions related to angles, and they are used correctly. In the informal definition, it is seen that some of the properties of this subject are used, leading to incomplete or incorrect expressions. Therefore, in this section, the formal and informal states of the expressions in the visual-angle examples are discussed. Below are some examples of formal expressions found in the stories.



We crossed the stream by riding on the flying ducks. When I arrived at my grandmother's house, my grandparents were playing soccer in the field next to my grandmother's house. I played a game of acute-angled backgammon at my grandmother's house. The right-angled desks in the sky accompanied me. Ducks came, and the acute-angled ducks accompanied me. My grandmother came home and we left the house to take me to the right-angled school. We arrived at the acute-angled school and sat at the wide-angle desks. As soon as my grandmother left me, she went back to the wide-angle field and the flying ducks also came. Then the teacher entered the class. As soon as the teacher entered the class, the wide-angle backgammon fell on the teacher's head. The teacher got very angry. Suddenly, my grandmother entered the classroom, took me, and left.

Ahmed was a fourth-grade student who had a great fondness for going to the park after school. One day, he went to the park with his parents and while sliding through some acute places, he accidentally fell and injured his knee. Despite receiving treatment for two months, the wound did not heal. Two months later, he rode his bike to attend a football match and noticed that the bike had an acute angle. Upon arrival at the football field, he realized that the match was starting in 30 seconds at 12:30 pm. During his math class, Ahmed noticed that the clock resembled a supplementary angle. The match began and a goal was scored. Upon returning home, he reviewed the match and noticed that he had a right angle on his foot. He went to bed early for a running competition the next day. When he woke up and checked the time, he realized he was late, but still managed to rush to the race. Starting off in the lead, The angle he was stuck in between the bushes to speed up was an acute angle. And he realized that running was everywhere...

Figure 7. Examples of formal expressions (S7 and S17)

When examining Figure 7, it is seen that student S7 correctly identified the relevant angles in the images by considering the basic characteristics of acute, obtuse, and right angles. Similarly, it is observed that student S17 correctly identified the relevant angles in the images by taking into account the information related to acute, complementary, and right angles. Therefore, it can be stated that students with codes S7 and S17 used formal expressions in their stories.

The informal expressions and explanations used by students in their stories are given in Table 7.

Table 7. Informal expressions in Visual-Angle examples

Participants	Informal Expressions in Visual-Angle Examples	Explanations
S_3	*1."Since the Ferris wheel is circular, there is a full angle at the center."* *2."A kite shaped like a hexagon has 6 equilateral triangles inside due to the sticks, and the sum of the interior angles of the triangles becomes a straight angle."* *3."Since the legs of the chair are in the middle, angles that correspond to each other are formed between the arms of the chair and the ground."*	When examining Figure 1, it can be seen that S3 provides an example of "full angle" which does not belong to any concept related to angles and therefore lacks a concept explanation. The reason for the student's idea is thought to be due to the presence of a straight angle in the relevant visual and the student mistakenly associating it with a "full angle". In the case of the kite (I23), S3 states that the sum of the interior angles of the triangles formed by the rods is a straight angle. It is thought that the student knows that the sum of the interior angles of a triangle is 180º. On the other hand, S3 states that the sum of the measures of two angles that measure 180° is called a straight angle, without considering the concept of full angle. Therefore, it has been determined that the student has a misconception about the concept of full angle. Finally, S3 mentions an example of "corresponding angle" which does not belong to any concept related to angles and therefore lacks a concept explained in the chair visual (I16).
S_4	1.*''He noticed that there are alternate angles in the legs of flamingos."*	According to the analysis, it is observed that Ö4 stated the existence of an angle type called "opposite angles" in the flamingo visual (I30). The reason for this may be the presence of angles facing the same direction in the relevant visual.
$S_{8.}$	*1."Then I noticed the angle on my glasses. It was a corresponding angle."* *2."On my way to school, when I looked at a car window, I saw a corresponding angle on the window."* *3."While I was walking, I saw a paper boat origami on the water, and it had corresponding angles."* *4."I opened the ironing board and saw corresponding angles there too."*	It can be observed that S8 has identified a type of angle called "opposite angles" in the images used while writing a story. However, it has been revealed that the student provided incorrect examples by stating that this type of angle can be found in many visuals (I13, I15, I17, I19). Therefore, it can be said that the student has inadequate or incorrect learning on the topic of angles, despite the presence of many angle examples in the relevant visuals, as they referred to "opposite angles" instead.
S_9	*1."The eyeglasses temple is an example of the U-rule, which refers to opposite congruent angles."* *2."The pages of the book are an example of adjacent complementary angle"* *3."The legs of ironing boards are an example of the Z-rule."*	S9 stated that the glasses image (I13) demonstrates the "U-rule" because it contains opposite congruent angles. The reason for the student's thinking may be the presence of corresponding angles on the eyeglasses's temple. S9 indicated that the image of book pages (I6) contains "adjacent complementary" angles. However, it is believed that the student determined this type of angle without considering the explanation that "two angles that are both neighboring and adjacent to whole angles are called neighboring wholes angles." It was determined that S9 has

Participants	Informal Expressions in Visual-Angle Examples	Explanations
		conceptual deficiencies regarding neighboring wholes angles, as the existing angles in the image of book pages are not neighboring wholes angles. S9 stated that the image of the ironing board (I17) demonstrates the "Z-rule." It is believed that the student determined this type of angle as the "Z-rule" because it is associated with interior alternate angles. Thus, it was revealed that S9 selected a visual-angle example without considering the conceptual image of interior alternate angles.
S_{11}	*1."Yesterday at school, I learned that the windows of the car have opposite congruent angles."* *2."There was an ironing board in the store, and I told my dad that there are opposite congruent angles here."*	It appears that S11 identified a type of angle as "opposite congruent angle" in the visuals used while writing the story. It was observed that the student gave examples of this angle type in multiple visuals (I17,I19). Therefore, it can be said that the student determined the angles as "opposite congruent angles" without considering the explanations of the concepts related to angles, despite the presence of many angle examples in the visuals.
S_{12}	1.*"One day, monkeys were sitting on vines with opposite congruent angles."*	S12 identified the angle type of "opposite congruent angles" in the monkey vines visual (S20) as "opposite congruent angles". This may be due to the presence of angles facing the same direction on opposite sides in the relevant image. It appears that the student named these angles as "opposite congruent angles" which has no equivalent in the concept explanations.
S_{13}	*1. "I mistakenly marked the sketch, and then I saw that there were alternate exterior angles in it."*	Based on the given information, it seems that S13 identified one of the angles in the example sketch (I3) as an exterior angle. Alternate exterior angles are angles formed when a transversal intersects two parallel lines, and they are not located between the parallel lines. However, there is no exterior angle in the given image. Therefore, it can be concluded that S13 selected a visual-angle example without considering the conceptual image of alternate exterior angles.
S_{14}	*1."While I was making a fan for myself, we drove through a street in a car, first passing through a wide-angle 3rd Avenue, and then through a right-angle 2nd Avenue."*	S14 identified wide angle and right angle as examples for the angles in the diagram (I3). However, these angle types are not present in this example. The reason for the student's incorrect angle examples can be explained by their misconceptions about wide angles and right angles.
S_{15}	*1."She saw an athlete on TV extending their leg 180 degrees, which reminded her of the straight angle."* *2."There were a wide variety of angles on the hangers."*	It can be observed that S15 provided a wrong example of angle in a sports branch example (I5) where she claimed that an athlete's leg forming a 180° angle creates a complementary angle. It became apparent that the student had a conceptual misunderstanding by stating that this angle was a complementary angle without considering the fact that an angle with a measure of 180° is a straight angle.

Participants	Informal Expressions in Visual-Angle Examples	Explanations
	3."When they arrived home, they saw people performing acrobatics in front of their doors, including alternate interior, alternate exterior, and corresponding angles."	S15 also made an incorrect statement about the existence of many obtuse angles in a hanger visual (I12), indicating a lack of understanding of this concept. Furthermore, S15 indicated that there were interior alternate, exterior alternate, and corresponding angles in a circus performance example visual (I9). However, as there were no such angles present in the related visual, it shows that the student misidentified the types of angles.
S_{16}	1.*"Glasses- Opposite congruent angles."*	S16 has indicated the presence of "corresponding angles" in the eyeglasses visual (I13). The reason for the student's thinking may be the presence of angles that are opposite to each other on the eyeglasses's temple.
S_{18}	1*"The people there cut the feathers of the duck with scissors that have an interior angle."*	It is observed that S18 indicated the presence of an interior angle in the scissors visual (I2). Based on the information that an interior angle is an angle between parallel lines that lies between them and is formed by an intersecting line, it can be stated that there is no interior angle in the scissors visual. Therefore, S18, who exemplified this type of angle in the scissors visual, was found to have a wrong or incomplete understanding of the interior angle concept in teaching.
S_{19}	*1.In the first picture, there were monkeys and we found parallel angles related to them.* *2.In the third paper, there was a stool and I said there was a Z angle, while my sibling said there was a wide angle.* *3.In the last paper, there was a male gymnast and my sibling found complementary and obtuse angles in it.*	In relation to the visual representation of monkey clusters (I20), S19 has stated the presence of a type of angle referred to as a "parallel angle." However, it can be observed that S19 has mistakenly associated this angle type with the concept of parallelism, which pertains to the relative positions of lines rather than types of angles. Consequently, it is evident that S19 has conceptual deficiencies regarding the relationships between line orientations and angle types. Regarding the chair visual (I16), S19 has indicated the presence of an obtuse angle and referred to it as the "Z-rule." It is presumed that S19 associates this angle type with the concept of interior angles. However, since there is no actual obtuse angle in the given visual, it becomes apparent that S19 has provided examples of visual angles without adhering to the accurate concept of interior angles and obtuse angles. In the sports example visual (I5), Ö19 has expressed the existence of complementary angles and obtuse angles. It is believed that S19 holds an erroneous belief that the athlete's leg forming a 180° angle creates a complementary angle. Moreover, the absence of an actual obtuse angle in the visual indicates S19's conceptual deficiencies regarding these concepts.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study, the written mathematical communication skills of seventh-grade students in their stories created in LTIG were investigated. In this context, LTIG was adapted to the topics of angles and lines and applied to the students.

The present study investigates the written mathematical communication skills of seventh grade students in their stories created in LTIG. In this context, LTIG was adapted to the topics of angles, lines, and angles and applied to the students. It was found that students included at least two and up to 10 concepts in their stories written in LTIG, and these concepts were not limited to the topics of angles and lines but also related to other topics in mathematics. However, even though there were many concepts that could be included in the visuals used by students in LTIG, being limited to a maximum of 10 concepts indicates that there were not enough concepts used in the stories. Similarly, Dur (2010) stated that students used a small number of mathematical relationships and concepts when expressing their ideas mathematically in writing. Therefore, based on the findings of the present study, it is consistent with the results of previous relevant research that students are able to use only a small number of mathematical concepts when expressing their thoughts in writing in LTIG. Writing activities have been stated to allow students to recall their experiences related to mathematics, reflect on these experiences and establish a relationship between the desired problem situation and experiences (Powell, 1997), provide feedback by slowing down the thinking process and organizing ideas (Liebars, 1997), and thus contribute to the development of higher-order cognitive skills (Smoak, 2017). The study by Öztürk, and Işık (2016) revealed that teachers believed writing practices could support learning. Therefore, it can be said that incorporating writing activities such as story writing into the teaching process can facilitate learning by contributing to students' cognitive and metacognitive skills. In line with the recommendation of using event-based applications such as stories, fairy tales, and riddles in math classes (Hacısalihoğlu Karadeniz, 2018), it is suggested that writing practices related to the concepts taught in math classes should be used in the form of stories, acrostic poems, short stories, riddles, etc. In this way, it is believed that students' thinking processes about the newly learned concept can be developed and meaningful and permanent learning can be achieved rather than memorizing a concept as a set of rules.

According to the study, when the percentages of students' ability to determine angles in the visuals used in LTIG were examined, it was revealed that only up to 33% of the angles in the visuals could be identified. Therefore, it can be said that students were also unsuccessful in determining angles in visuals selected from real-life situations, and they could not establish a relationship between the knowledge they acquired about angles and their ability to determine angles in visuals. It is believed that the reason for this is that students cannot relate their angle concepts to everyday life situations. Kabael and Ata-Baran (2016) stated that teachers' perceptions regarding the use of mathematical language in different disciplines and in real-life situations play a significant role in the development of their mathematical communication skills. Thus, it can be argued that teachers' failure to relate mathematics to real-life situations has a negative impact on students' ability to establish connections between concepts and their applications. Therefore, teachers should focus on conceptual understanding by emphasizing the relationship between the concept of angles and their real-life applications in learning environments (Yavuz-Mumcu, 2018). Based on this, it is recommended to conduct studies to explore angle examples in everyday life and determine the measurements and types of angles in objects selected from real-life situations in teaching the concept of angles.

In the study, expressions identifying visual-angle examples from students' created stories were evaluated according to the "evaluation rubric for written communication skills in the context of visual-angle examples." As for students' written mathematical communication skills, it is observed that 48% of them have a moderate level of mathematical language proficiency, 28% have a high level, 19% have a low level, and 5% have insufficient use of mathematical language. Thus, it can be said that the majority of students have a moderate level of mathematical communication skills. Similarly, it has been stated that the level of understanding and using mathematical language for exponentials among eighth-grade students is at a moderate level (Güzel & Yılmaz, 2020). Furthermore, Yılmaz and Türkmen (2019) reported that seventh-grade students' use of mathematical language regarding lines and angles is generally at a moderate level. These studies support the results of the present study. However, Yılmaz and Türkmen (2019) stated that the highest level of students' mathematical language use was only 11.1%, which differs from the result of the present study.

In the study, it was found that 19% of the students used mathematical language at a low level and 5% had inadequate use of mathematical language due to the absence of visual-angle examples in the visuals they used in their stories. Similarly, it has been stated that the mathematical language skills of seventh-grade students in the learning area of "Algebra" need to be developed (Akarsu-Yakar & Yılmaz, 2017; Yalvaç, 2019), there are deficiencies in the mathematical language used by students regarding quadrilaterals (Kula Yeşil, 2015), the use of mathematical language by students is limited and not clear (Açıl & Zeybek, 2017), and students have insufficient ability to use mathematical language in story writing (Dur, 2010). In addition, it has been stated that eighth-grade students have deficiencies in their use of mathematical language in expressions involving square roots (Yılmaz & Güzel, 2020), and students have difficulty using appropriate mathematical language when expressing their mathematical thoughts (Yüzerler, 2013). Therefore, this result of the study is supported by previous research. Yıldız (2016) stated that every expression used by the teacher in class has an important role in the process of creating schemas in students' minds regarding the concepts they have learned. In the same study, it was noted that teachers' failure to pay attention to the language they use during the teaching process could lead to the incorrect or inadequate formation of mathematical language in students. Additionally, the low level of proficiency in using mathematical language by students may be related to the lack of an environment that promotes the

use of this language in the teaching and learning process, as well as teachers' focus on operational skills rather than ensuring the proper use and implementation of mathematical language (Güldal, 2022). During classroom activities, allowing students to freely express their ideas and verbally and/or in writing explain their problem-solving methods with reasons could advance their mathematical communication skills (Aksoy, 2021). Furthermore, it is suggested that the use of certain words, word patterns, and corresponding explanations by the teacher can help students become familiar with mathematical language, develop their expression styles, and effectively communicate math concepts using language (Jamison, 2000).

In the study, it is stated that S9 in I6 "adjacent angles", S13 in I3 "exterior angles", S14 in I3 "obtuse angles and right angles", S15 in I12 "obtuse angles", and in I9 "alternate interior angles, alternate exterior angles, and corresponding angles", S18 in I2 "interior angles" and in S19 in I30 "vertical angles", and in I16 and I15 "obtuse angles" are mentioned. However, these angles are not found in the relevant visuals. Therefore, it can be said that these students have made incomplete or incorrect learning regarding these angles and cannot determine the angles in the visuals. In addition, Ünal (2013) has also shown that students have difficulty identifying exterior angles. Ünal (2013) states that students confuse obtuse angle with reflex angle and often identify adjacent angles as exterior angles when determining them on parallel lines. Yılmaz (2011) found that 45% of seventh grade students could not identify alternate angles, 28.3% could not identify interior angles, 43.3% could not identify exterior angles, and 60% could not identify corresponding angles. In a study by Özbellek (2003), it was determined that sixth and seventh grade students had difficulty in demonstrating the concepts of obtuse angle, interior angle, exterior angle, and alternate angle on a diagram. Therefore, these results are consistent with the findings of this study.

In the current study, it was found that students used both formal and informal language when identifying angles in the images used in LTIG. In the formal definitions, the terms were correctly used by considering their properties, while in the informal definitions, some terms were used incompletely or incorrectly by considering their properties. In this context, it was revealed that the students used informal language such as "perigon", "opposite angle", "Z Rule", "corresponding angle", "U Rule" and "parallel angle" that do not belong to any of the concepts related to angles in their stories. It has been determined that the concepts in question are not included in various mathematics textbooks approved by the Board of Education or in the current curriculum (MoNE, 2018). It is thought that the Z Rule among these concepts is related to "interior alternate angles" and that the parallel angle is related to "three lines on the same plane being parallel to each other." In a study where students were asked to explain the concept of angles, it was stated that although students' knowledge of the "angle" concept was insufficient, teachers talked about angles without explaining what they were (Dickson, Brown, Gibson, 1993; cited in Yeşildere, 2007). This situation emphasizes the need for teachers to be careful in their use of mathematical language during the concept teaching process.

The study includes statements such as "The sum of the interior angles of a triangle is a whole angle" for S3 and "I saw an athlete on TV with his leg at 180 degrees, which reminded me of the concept of a whole angle" for S15. However, it is seen that S19 stated that the sport with a 180° angle is an example of a whole angle, even though it is not a whole angle. Based on this, it has been revealed that these students have incomplete, weak, and incorrect learning about the concept of "whole angle" without considering the explanation that "an angle consisting of two angles whose measures add up to 180 degrees is called a whole angle". Similarly, Kula Yeşil (2015) stated that students have difficulty expressing the concept of "whole angle" mathematically, and Yılmaz (2011) stated that students mostly cannot determine whole angles. In addition, it has been found that there are concept misconceptions related to the "Algebra" learning area in the study that focuses on the mathematical language usage of seventh-grade students (Akarsu, 2013). Yalvaç (2019), in his study examining the mathematical language usage skills of eighth-grade students, revealed that students have concept misconceptions in addition to operations with algebraic expressions. The study on the effects of concept cartoons applications on fifth-grade students' use of mathematical language (Aygün, 2018) reported that students had a misconception about the representation of dots by using lowercase letters. In their study examining students' level of mathematical language use and their opinions about the language related to square root expressions, Yılmaz and Güzel (2020) found that students had a misconception about square root expressions. Therefore, the related studies on students' mathematical language skills support the detection of misconceptions in the present study.

In conclusion, the study found that seventh grade students included only a small number of mathematical concepts, up to 10, in their stories written in LTIG, and were able to determine only 33% of the angles in the visuals provided. Despite the limited use of mathematical concepts and the low success rate in identifying angles, the study revealed that students had a moderate level of proficiency in written mathematical communication skills. This is due to the fact that most of the expressions used by the students in describing the visual angle examples were correct. Previous literature has shown that mathematical stories have many benefits for students (Franz & Pope, 2005; Goral & Gnadinger, 2006; Healy & Sinclair, 2007). In light of the data obtained from this study, it is emphasized that writing applications used in learning environments can be used in various forms in math lessons. Especially, it is recommended to write stories related to the taught concept. Thus, the accuracy of the information acquired by learners can be checked, and incomplete or incorrect learning and conceptual misunderstandings can be detected. In addition, it has been shown that the incorrect use of mathematical language by mathematics teacher candidates has a negative impact on students' ability to use mathematical language correctly (Kula Ünver & Bukova Güzel, 2019). Moreover, it has been stated that these language deficiencies are one of the main reasons why students find it difficult to understand mathematical concepts (Moore, 1994). In this context, it is considered important for teacher candidates to use correct mathematical language and to have a high level of mathematical communication skills. Therefore, it is recommended that teacher education programs provide information

to candidates on the advantages/disadvantages of correct/incorrect usage of mathematical language and raise awareness on the importance of this issue.

In future studies, one of the limitations of the current study can be addressed by including additional geometry concepts such as polygons, right triangles, acute triangles, obtuse triangles, isosceles triangles, equilateral triangles, scalene triangles, parallelograms, quadrilaterals, trapezoids, and diagonals in the LTIG process. In this adaptation, students' ability to identify both angle types and related concepts in real-life visuals can be assessed through written communication skills or mathematical language contexts. As a final remark, it is hoped that this study will contribute to future studies in the context of mathematical written communication, mathematical language and educational games (traditional children's games, intelligence games) adapted to mathematics.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

I/We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

The research proposal titled "Analyzing the Written Mathematical Communication Skills in the Stories Created by Seventh Grade Students in the Let's Tell Intelligence Game" was discussed by the Gıresun University Ethics Committee Commission at the meeting dated 09.05.2023 and numbered 05/04 and was unanimously approved. The approval code for the study is E-50288587-050.01.04-154547.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 240-252
doi: 10.24106/kefdergi.1682922

| Research Article / Araştırma Makalesi |

The Effect of Writing to Learn Activities on 5th Grade Students' Academic Achievement on Triangles and Quadrilaterals and Students' Opinions[1]

Öğrenme Amaçlı Yazma Aktivitelerinin 5. Sınıf Öğrencilerinin Üçgenler ve Dörtgenler Konusunda Akademik Başarılarına Etkisinin ve Öğrenci Görüşlerinin İncelenmesi

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Keywords
1. Writing to learn
2. Diary writing activity
3. Letter writing activity
4. Triangles and quadrilaterals

Anahtar Kelimeler
1. Öğrenme amaçlı yazma
2. Günlük yazma aktivitesi
3. Mektup yazma aktiviesi
4. Üçgenler ve dörtgenler

Received/Başvuru Tarihi
01.08.2024

Accepted / Kabul Tarihi
20.04.2025

Abstract

Purpose: The purpose of this study is to examine the effect of diary and letter writing activities, which are writing to learn activities, on the academic achievement of 5th grade students in the subject of triangles and quadrilaterals and to examine students' opinions about the activities.

Methodology: An explanatory design from mixed research methods was used in the study. The sample of the study consisted of a total of 96 students studying in the 5th grade of a public school in Şanlıurfa city center. One of these classes was randomly selected as the control group and three as the experimental group. The data collection tools of the study consisted of an academic achievement test and a semi-structured interview form. Since the data obtained from the academic achievement test conformed to the normal distribution, ANOVA was used to analyze these data. Content analysis method was used to analyze the data obtained from semi-structured interview forms.

Findings: According to the findings obtained from the academic achievement test, it was determined that diary and letter writing activities increased academic achievement. However, no difference was found between diary and letter writing activities in terms of academic achievement. According to the findings obtained from the semi-structured interview form, it was determined that diary and letter writing activities have positive features such as understanding the subject, repetition and permanent learning, as well as some difficulties based on students' written expression skills.

Highlights: In line with the results obtained from the study, it is concluded that journal and letter writing, which are writing to learn activities, can increase academic achievement in mathematics courses and provide teachers with important opportunities to assess students' learning by identifying their comprehension and misconceptions and to provide feedback to them.

Öz

Çalışmanın amacı: Bu araştırmanın amacı öğrenme amaçlı yazma aktivitelerinden günlük ve mektup yazma aktivitelerinin, 5. sınıf öğrencilerinin üçgenler ve dörtgenler konusunda akademik başarılarına etkisinin ve aktivitelere yönelik öğrenci görüşlerinin incelenmesidir.

Yöntem: Araştırmada karma araştırma yöntemlerinden açıklayıcı desen kullanılmıştır. Araştırmanın örneklemini Şanlıurfa il merkezindeki bir devlet okulunun 5. sınıflarında öğrenim gören toplam 96 öğrenci oluşturmaktadır. Bu sınıflardan birisi kontrol ve üçü deney grubu olarak rastgele belirlenmiştir. Araştırmanın veri toplama araçlarını akademik başarı testi ve yarı yapılandırılmış görüşme formu oluşturmaktadır. Akademik başarı testinden elde edilen veriler normal dağılıma uygun olduğundan bu verilerin analizinde ANOVA kullanılmıştır. Yarı yapılandırılmış görüşme formlarından elde edilen verilerin analizinde ise içerik analizi yönteminden faydalanılmıştır.

Bulgular: Akademik başarı testinden elde edilen bulgulara göre günlük ve mektup yazmanın akademik başarıyı artırdığı belirlenmiştir. Ancak günlük ve mektup yazma aktiviteleri arasında akademik başarı yönünden herhangi bir fark bulunamamıştır. Yarı yapılandırılmış görüşme formundan elde edilen bulgulara göre ise günlük ve mektup yazma aktivitelerinin konuyu anlamayı, tekrar yapmayı ve kalıcı öğrenmeyi sağladığı gibi olumlu özelliklerinin yanı sıra öğrencilerin yazılı ifade becerilerine dayalı bazı zorluklarının olduğu tespit edilmiştir.

Önemli Vurgular: Araştırmadan elde edilen sonuçlar doğrultusunda, öğrenme amaçlı yazma aktivitelerinden günlük ve mektup yazmanın matematik derslerinde akademik başarıyı arttırabileceği ve öğrencilerin kavrayışlarını ve kavram yanılgılarını belirleyerek öğrenmelerini değerlendirmede ve onlara geri dönüt sağlamada öğretmenlere önemli fırsatlar sunacağı değerlendirilmektedir.

[1] This research is derived from the master's thesis of the first author under the supervision of the second author.

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Citation/Alıntı: Aslan, M., & Öztürk, F. (2025). The Effect of Writing to Learn Activities on 5th Grade Students' Academic Achievement on Triangles and Quadrilaterals and Students' Opinions, *Kastamonu Education Journal, 33*(2), 240-252. doi: 10.24106/kefdergi.1682922

INTRODUCTION

In developed countries, education continues in a flexible structure that is open to innovations and change, and it is considered that knowledge should be used in experiences rather than memorizing and learning in schools. In this context, the principle of learning by doing and experiencing, which is one of the leading contemporary educational approaches, also manifests itself in the act of writing. Thanks to writing, students can organize and realize their own knowledge by concretizing what is in their minds and thinking more slowly (Kartalcı, 2018). Because thoughts are developed and processed in the process (Emig, 1977). Therefore, if students are encouraged to develop their ideas about writing, their conceptual understanding will improve (Shield & Galbraith, 1998). As a matter of fact, writing is considered as a unique form of learning because it has different learning strategies both as a process and as a result, and it is emphasized that the aspect of structuring knowledge is strong. In this context, the fact that writing is an activity with benefits such as repetition, revealing learning, reshaping, explaining, establishing cause and effect relationships, and reasoning has made writing important (Mason & Boscolo, 2000). In addition, writing also strengthens the communication between the student and the teacher. Even if the student who wants to meet with the teacher cannot have this opportunity at school, he/she has the opportunity to communicate about the lesson, what he/she has learnt or not learnt through writing (Miller, 1991). Writing, which is a sub-skill of communication, enables students to interpret their own learning and learn meaningfully by giving them the opportunity to think (Rivard & Straw, 2000). In addition, writing about a concept helps students to realize their own knowledge (Bicer, Capraro & Capraro, 2013). By writing, students can change their feelings about their own learning, realize the topics they understand and do not understand, gain perspective with the work of their friends, expand the topics they understand and make connections with previous topics (Braun, 2014), and consciously transfer these thoughts to the other party.

One of the most effective ways that writing serves learning is writing to learn activities (Kasa, 2009). Writing to learn contributes to increasing the retention of information and associating previous knowledge with new ones (Raquid & Litao, 2023; Rivard & Straw, 2000; Van Dijk, Van Gelderen & Kuiken, 2022) and learning difficult concepts (Hohenshell, Hand & Staker, 2004; Van Dijk et al, 2022). In addition, writing to learn is also effective in structuring information easily, concretizing abstract concepts and making learning permanent (Ay, 2018).

The role of the teacher as the conductor of writing to learn activities in the classroom is important. The teacher should decide how to structure which activity in the classroom and for what purpose. Prain and Hand (1996) put forward a model to guide teachers in this regard. According to this model, writing activities for learning consist of five components: topic, activity, purpose, addressee and text production method. Firstly, it should be decided on which topic to write on. Then it should be determined which activity will be more appropriate. In this sense, although traditional writing activities such as summarizing and note-taking are mostly used in schools, writing to learn activities such as stories, letters, brochures, diaries, diagrams, poems and posters should be used more. After deciding on a suitable writing activity, the purpose should be determined. Depending on the purpose of writing, the activity can be applied at the beginning of the lesson, during the lesson or after the lesson. While applying it at the beginning of the lesson is done to determine readiness, applying it during the lesson serves the purpose of reinforcing the learnt information. After the lesson, on the other hand, it can be done to evaluate learning, transfer knowledge to new situations and persuade someone. Another component is the addressee. In other words, it is necessary to consider to whom the text will be addressed. The last component is the text production method. In other words, the act of writing can be done collaboratively with the group or individually.

Writing to learn activities used in education have been categorized in different ways in many studies. Wills (1993) grouped writing to learn activities according to the purpose of writing in three ways: reflective or meaningful writing (diary writing, story writing, problem solving, definitions, future writing, review writing, summaries, letter writing), informative formal writing, creative writing. Burns (2004) categorized writing for learning activities into four groups: keeping a diary, writing about mathematical problems, explaining mathematical ideas and writing about the learning process. Uğurel, Tekin, and Moralı (2009), without making a specific classification, listed the preferred writing activities in mathematics education as meaningful writing, formal writing for communication, poetic writing, diary writing, informative writing, stimulating writing, stimulating improvisation, e-mail diaries, mathematical biographies, letter writing, summarizing writing, article writing, rewriting, warm-up writing, problem solving, reflective writing, learning logs, creative writing, informal writing and formal writing. In this study, diary and letter writing activities among writing to learn activities are discussed.

Journal writing is an educational tool based on students' writing to learn and can be defined as a type of writing in which students write about their feelings, thoughts and learning throughout the process without following formal writing rules (Lynch, 2003). Diaries reflect students' thoughts on some topics and concepts under the guidance of teachers (Ho, 2019; Ishii, 2003). Wills (1993) states that students who have not done writing to learn before can start with a diary and that diaries can be written for different reasons such as providing information exchange between teachers and students and personalizing learning. Journal writing, one of the most widely used writing activities (Borasi & Rose, 1989), provides students with the opportunity to become aware of their own learning while transferring what they have learnt (Ediger, 2006). Therefore, students can both have information about their own learning and have the opportunity to repeat the lesson that day. On the other hand, when students check their diaries for the past, they can realize their own progress. Thus, by giving students the opportunity to evaluate their own learning, it enables students to take personal responsibility and to be aware of what and how they learn (Crawford, 2005). In addition, while journal writing provides students with the opportunity to learn, it also provides teachers with the opportunity to access information about the student and establish a good dialogue (Hiemstra, 2001).

Letter writing activity is when a student writes a letter to a younger person, teacher or peer (Carpenter, 2012). Letter writing, which aims to make an explanation, is thought to provide conceptual understanding and reconstruction of information by preventing the repetition of information without understanding (Hohensel, Hand & Staker, 2004). Students need to get down to the level of the addressee in order for the addressee to understand. Thus, they need to perform some cognitive activities while thinking about the way of expression. These cognitive activities can be expressed as recalling, reinterpreting and structuring existing knowledge, and the whole of these activities provides learning (Galbright, 1999). One of the most typical examples of letter writing is when a student writes a letter to a peer (real or imaginary) who is not in the classroom in order to explain a certain concept, summarize a lesson or unit, or explain a lesson that was missed (Enyart & Van Zoest, 1998).

Writing to learn activities, which are included in the curricula of many countries, have not yet been sufficiently addressed in mathematics education in Turkey. In terms of developing scientific literacy, which is one of the objectives targeted in education systems, and providing meaningful learning, writing to learn is an area waiting to be explored (Günel, 2009). The importance of writing to learn activities in terms of increasing student success, providing students with the opportunity to express themselves, and contributing positively to learning and teaching is better understood day by day (Biber, 2012; Öztürk, Öztürk & Işık; 2016). In Turkey, studies on writing to learn activities are concentrated especially in the field of science teaching and similar studies should be increased in the field of mathematics teaching (Akkuş & Darendeli, 2020). However, there are a limited number of studies examining the effects of writing to learn activities on mathematics achievement (Çontay, 2012; Çontay & Duatepe-Paksu, 2018; Kasa, 2009; Yıldırım, 2016; Yılmaz, 2014). In addition, the fact that there is no study on writing to learn activities on triangles and quadrilaterals and the fact that writing to learn activities that provide conceptual understanding can contribute to the teaching of triangles and quadrilaterals and increase academic achievement has made it important to conduct a study on this subject. In this context, the aim of the study is to examine the effect of diary and letter writing activities, which are among the activities of writing to learn, on the academic achievement of 5th grade students in the subject of triangles and quadrilaterals and to examine student opinions about the activities. In this context, answers to the following problems were sought in the research:

1. Is there a significant difference between the academic achievement of 5th grade students in the groups in which diary and letter writing activities were used together, only diary writing activity was used, only letter writing activity was used and no writing activity was used for any learning purpose?
2. How are the opinions of the 5th grade students in the groups where diary writing, letter writing and both activities were used together about the writing to learn activities?

METHOD

Research Design

Explanatory design, one of the mixed research methods, was used in the study. In explanatory design, quantitative data are collected first and then qualitative data are collected (Baki & Gökçek, 2012). The quantitative part of the study was designed with a quasi-experimental design using a pretest-posttest control group model. In accordance with this model, three classes were determined as the experimental group and one class as the control group and a total of four groups were formed. The research model is summarized in Table 1.

Table 1. Research model

Groups	Pre-Test	Writing Activity	Final Test	Interview
First Experimental Group	Preliminary Knowledge Test	Diary and Letter Writing	Academic Achievement Test	Semi-structured Interview
Second Experimental Group	Preliminary Knowledge Test	Diary Writing	Academic Achievement Test	Semi-structured Interview
Third Experimental Group	Preliminary Knowledge Test	Letter Writing	Academic Achievement Test	Semi-structured Interview
Control Group	Preliminary Knowledge Test	-	Academic Achievement Test	-

Sample

The sample of the study consisted of a total of 96 students studying in the 5th grade of a state secondary school in Şanlıurfa city center. Four branches were randomly selected among the 5th grade classes in the secondary school where the study was conducted, and 1 control and 3 experimental groups were randomly selected among these classes. There were 23 male students in the experimental group in which letter and diary writing activities were performed together and this group was coded as LDG, 25 male students in the experimental group in which only diary writing activity was performed and this group was coded as DG, and 25 male students in the experimental group in which only letter writing activity was performed and this group was coded as LG. In the control group, there were 23 male students and this group was coded as CG. Since the school was an İmam Hatip Secondary School, all of the students were male. All students participated in the study voluntarily. Necessary permissions were obtained from official institutions for the study.

In determining the control and experimental groups, the statistical results of the preliminary knowledge test (PKT) scores of the groups were taken into consideration. The PKT was formed by taking into account the 5th grade first semester acquisitions of the students and consisted of 16 multiple-choice questions appropriate to the level of the students. This test was prepared by the researcher by selecting the questions from the achievement tests published by Ministry of National Education (MNE) and the questions that appeared in the central exams held by MNE in the past years. In the process of preparing the test, the opinions of two mathematics teachers working in secondary schools affiliated to MNE and an expert in mathematics education were taken. In the expert opinions, attention was paid to the fact that the questions in the test included all the topics in the first semester of the 5th grade, were appropriate for the level of the students, and the time given to the students to solve the questions was appropriate. The prepared SCT was administered one week before the implementation process of the study. In this direction, the results of the normality test analysis according to the PKT scores of the control and experimental groups were $p>0.05$ for LDG ($p=0.163$), DG ($p=0.305$), LG ($p=0.282$) and CG ($p=0.076$) and since they showed normal distribution and the assumption of homogeneity of variances was met, One-Way Analysis of Variance (ANOVA) was used to determine whether there was a significant difference between the groups in the pre-knowledge test. The significance value calculated as a result of ANOVA was $p>0.05$ and no significant difference was found between the pre-knowledge test scores of the control and experimental groups ($F(3, 92)=2.330$; $p=0.079$). Therefore, since the groups were equivalent in terms of achievement, the control and experimental groups were randomly determined.

On the other hand, semi-structured interviews were conducted with 6 students from the LDG, 5 students from the DG and 7 students from the LG who performed the activities regularly. The students in the LDG with whom semi-structured interviews were conducted were coded as LD_1, LD_2, LD_3, LD_4, LD_5, LD_6, the students in the DG were coded as D_1, D_2, D_3, D_4, D_5 and the students in the LG were coded as L_1, L_2, L_3, L_4, L_5, L_6, L_7.

Data Collection Tools

The quantitative data collection tool of the study is academic achievement test and the qualitative data collection tool is a semi-structured interview form.

Academic Achievement Test (AAT)

In the study, the AAT consisting of 16 multiple-choice questions about triangles and quadrilaterals was applied as a post-test. The questions in the test were prepared in line with the subject acquisitions of triangles and quadrilaterals in the mathematics curriculum and were selected from the questions in the central exams held by the MNE in previous years. In the process of preparing the test, the opinions of two mathematics teachers working in secondary schools affiliated to the MNE and an expert lecturer in mathematics education were taken. In order to ensure the content validity of the AAT, four questions were prepared from each learning outcome. In addition, the KR-20 reliability coefficient of the AAT was found to be 0.853. The reliability coefficient of 0.853 indicates that the reliability of the test is quite high (Johnson & Christensen, 2014). The distribution of the questions in the AAT according to the objectives is given in Table 2.

Table 2. Distribution of the questions in the AAT according to the objectives

Learning Outcome	Question Number
M.5.2.2.1 Names, forms and recognizes the basic elements of polygons.	1, 2, 3, 4
M.5.2.2.2 Construct triangles according to their angles and sides, classify different triangles according to their side and angle properties.	9, 10, 11, 12
M.5.2.2.3 Determines and draws the basic elements of rectangle, parallelogram, rhombus and trapezoid.	5, 6, 7, 8
M.5.2.2.4 Determines the sum of the measures of the interior angles of triangles and quadrilaterals and finds the angle not given.	13, 14, 15, 16

In order for the scoring to be reliable, an answer key was created before the implementation of the AAT and it was decided how the scoring would be done. In this direction, each correct answer is evaluated as 1 point, incorrect and blank answers are evaluated as 0 points and the maximum score that can be obtained from the test is 16 points.

Semi-structured Interview Form

In the study, a semi-structured interview form was used to determine the students' thoughts about the diary and letter writing activities. The questions in the interview form were prepared by the researchers in line with the relevant literature. Pilot application was made with the questions and since it was seen that similar answers were given to some questions; the questions were edited. In addition, the opinion of an expert in the field of mathematics education who has previous experience in preparing interview forms was taken during the process of creating the interview form. In line with the expert opinion, since it was stated that some questions contained guidance and similar answers were given to some questions as a result of the pilot study, the relevant questions in the interview form were revised and some questions were removed from the interview form. During the interviews, the students' consent was obtained and audio recordings were made to be analyzed later.

Data Collection Process

One week before the beginning of the study, a pre-test was applied to all groups to determine whether there was a significant difference between the groups in terms of achievement, and since there was no significant difference between the groups, the control and experimental groups were randomly selected. During the study, the subject of triangles and quadrilaterals in the

control and experimental groups was taught by the same teacher for three weeks in the same way within the curriculum. Each group received a total of 15 hours of instruction, 5 hours per week in the form of 2+2+1. The control and experimental groups were given the same activities in and out of the lesson, but the experimental groups were additionally given related learning-oriented writing activities as homework. In this direction, diary writing instructions were given to the DG and explained with examples, and at the end of each lesson, the diary writing activity was done as homework. The LG was given instructions on letter writing, explained with examples, and at the end of the week, letter writing activity was assigned as homework. Similarly, diary writing and letter writing instructions were given to the LDG, explained with examples, and diary writing activities at the end of each lesson and letter writing activities at the end of the week were done as homework. A total of 9 diaries were written by the students in the groups where the diary writing activity was performed, and a total of 3 letters were written by the students in the groups where the letter writing activity was performed. Examples of diaries and letters written by the students are included in the Appendix. At the end of the application, AAT was applied as a post-test. Finally, semi-structured interviews were conducted separately with 18 students in the experimental groups using the interview forms prepared in advance.

Data Analysis

In the study, SPSS 23 programme was used to analyze the quantitative data obtained from AAT. In order to decide which analysis method to use for the data in the AAT, the normality distributions of the control and experimental groups were examined first. In this direction, since the results of the normality test analysis according to the AAT scores of the control and experimental groups; $p>0.05$ for LDG ($p=0.075$), DG ($p=0.133$), LG ($p=0.114$) and CG ($p=0.146$) showed a normal distribution and according to the Levene's Test result ($p=0.300$) $p>0.05$ and the assumption of homogeneity of variances was met, ANOVA was used to determine whether there was a significant difference between the groups in the academic achievement test. LSD test, one of the multiple comparison tests, was used to determine which group was in favor of the significant difference.

In the study, content analysis method was used to analyze the qualitative data obtained from semi-structured interviews conducted to determine the students' thoughts about the diary and letter writing activities. Content analysis is a process that starts with data collection and ends with category and code extraction, and the interpretation and synthesis of data is done by researchers (McMillan & Schumacher, 2010). In content analysis, similar data are brought together within the framework of certain concepts and themes and interpreted by organizing them in a way that the reader can understand (Yıldırım & Şimşek, 2011). The data obtained from the interviews were analyzed by content analysis and firstly codes and then categories were formed by bringing together similar codes, if any. This code and categorization process was repeated at different times in order to obtain accurate and reliable findings. While creating codes and categories, data considered to be outside the scope of the study were not taken into consideration. In order to make these codes and categories understandable, they are presented in tables in the findings section and explained.

FINDINGS

In this section, the findings obtained as a result of the analysis of the data collected to answer the sub-problems of the research are presented. The findings are presented separately in line with the sub-problems of the research, as the findings obtained from the AAT scores and the findings obtained from the interviews.

Results obtained from AAT Scores

In this section, the findings obtained for the sub-problem "Is there a significant difference between the academic achievement of 5th grade students in the groups in which diary and letter writing activities were used together, only diary writing activity was used, only letter writing activity was used and no writing activity was used for any learning purpose?" are presented.

The descriptive statistics of the AAT scores of the control and experimental groups are given in Table 3.

Table 3. Descriptive statistics obtained from AAT scores

Group	N	X	sd
LDG	23	8.13	3.334
DG	25	8.00	2.972
LG	25	8.52	2.632
CG	23	5.70	1.941

According to Table 3, the group with the highest mean was LG (X=8.52) and the group with the lowest mean was CG (X=5.70).

The ANOVA results to determine whether there is a significant difference between the AAT scores of the control and experimental groups are given in Table 4.

Table 4. ANOVA results for AAT scores

	Sum of Squares	df	Mean Squares	F	p	Significant Difference
Between groups	115.021	3	38.340	4.998	0.003	LDG*-CG
In-group	705.718	92	7.671			DG*-CG
Total	820.740	95				LG*-CG

*: Indicates the group in favor of the significant difference.

When Table 4 is examined; since the significance value calculated as a result of ANOVA is $p<0.05$, there is a significant difference between the AAT scores of the experimental and control groups ($F(3, 92)=4.998$; $p=0.003$). LSD test, one of the multiple comparison tests, was performed to determine which group was in favor of the significant difference. According to the LSD test results, a significant difference was found between LDG and CG in favor of LDG ($p=0.004$), between DG and CG in favor of DG ($p=0.005$) and between LG and CG in favor of LG ($p=0.001$). In addition, the effect size value was calculated as 0.14. According to Green and Salkind (2014), 0.14 is interpreted as a large effect size.

Findings from the Interviews

In this section, the findings obtained for the sub-problem "How are the opinions of the 5th grade students in the groups in which diary writing, letter writing and both activities were used together about the writing to learn activities they used?" are presented.

The students in the LG and LDG who used the letter writing activity were asked the question "*Can you explain how the letter writing activity affected you?*" and the findings of the answers given by the students to this question are given in Table 5.

Table 5. Effects of letter writing activity

Code	Student	Frequency
Understanding the topic	L_4, L_5, L_6, LD_1, LD_4, LD_5, LD_6	7
Do not repeat	L_1, L_2, L_5, L_7, LD_4	5
Helping others	L_2, LD_2	2
Attention enhancement	LD_3	1
Permanent learning	LD_5	1
Transferring emotions	L_3	1

When Table 5, which includes students' opinions on the effects of letter writing activity, is analyzed, it is seen that 7 students stated that letter writing helped them to understand the subject, 5 students stated that it helped them to repeat the subjects, 2 students stated that it helped them to cooperate and 1 student each stated that it helped them to increase attention, permanent learning, to write well and to convey their feelings.

The students coded L_5 and LD_5, who stated that the letter writing activity contributed to understanding the subject, expressed these thoughts;

It opened my mind, so I could understand the subjects better (L_5)

It made me understand the lessons better (LD_5)

The students expressed their opinions about the letter writing activity providing subject repetition. The students coded L_1 and L_7 expressed their opinions about the letter writing activity providing subject repetition;

Repetition of the topic (L_1)

It was a repetition of the course topics (L_7)

L_2 coded student expressed his/her opinion that letter writing activity provides cooperation;

It felt like helping someone (L_2)

expressed with the sentence. The student coded LD_3 stated that the letter writing activity increased attention;

I was listening more attentively to the lecture so I could write the letter (LD_3)

The student stated in the form of. LD_5 coded student;

Writing down the information I remembered made it more permanent (LD_5)

drew attention to the fact that letter writing activity provided permanence in the subjects. The student coded as L_3 stated that the letter writing activity enabled the transfer of emotions;

It was like writing my inner thoughts on a piece of paper, transferring my inner feelings (L_3)

with the statement of his opinion.

The students in the LG and LDG who used the letter writing activity were asked the question "*Did you encounter any difficulties in the letter writing activity? If so, what are these difficulties*?" and the findings of the answers given by the students to this question are presented in Table 6.

Table 6. Difficulties of the letter writing activity

Code	Student	Frequency
Inability to remember the topic	L_1, L_2, L_3, L_5, L_6, L_7	6
Inability to express oneself	LD_4	1
Compliance with spelling rules	LD_2	1
Did not meet	L_4, LD_1, LD_3, LD_5, LD_6	5

Table 6 shows that 8 students stated that they encountered various difficulties in the letter writing activity, while 5 students stated that they did not encounter any difficulties.

Students coded L_6 and L_7 had difficulty in remembering the subject while writing a letter;

I came across my teacher because it was difficult to think. Sometimes I couldn't remember, I was looking from the notebook (L_6)

I forgot topics. I had to look at the notebook. Sometimes I remembered that I wrote incompletely and corrected it (L_7)

expressed with these words. LD_4 coded student stated that he had difficulty in expressing himself;

For example, I couldn't find exactly how to express it and I was thinking about it a lot (LD_4)

While the student with the code LD_2 explained that he had difficulty in complying with the spelling rules;

I had some difficulty in punctuation (LD_2)

in the form of "I did not encounter any difficulties in the letter writing activity". On the other hand, students coded L_4 and LD_5 stated that they did not encounter any difficulties in the letter writing activity;

I had no difficulty because I put the information I remembered there (LD_5)

No, teacher, I did not encounter because I was repeating the topics before, then I was writing the letter (L_4)

They explained it with the following sentences.

The students in the DG and LDG who used the diary writing activity were asked the question "*Can you explain how the diary writing activity affected you?*" and the findings of the students' answers to this question are given in Table 7.

Table 7. Effects of the diary writing activity

Code	Student	Frequency
Understanding the topic	D_1, D_2, D_4, LD_4	4
Self-development	LD_1, LD_2, LD_5	3
Do not repeat	D_2, LD_6	2
Enjoyment	D_5, LD_3	2
Enduring learning	D_3	1

According to Table 7; 4 students stated that the diary writing activity provided understanding of the subject, 3 students stated that it provided development, 2 students stated that it provided repetition, 2 students stated that It provided having fun and 1 student stated that it provided permanent learning.

Students coded D_1 and LD_4 for the diary writing activity to ensure understanding of the subject;

It was like an activity for us to understand the subjects better (D_1)

I understood better all the subjects we covered during the day (LD_4

While the student with the code LD_1 expressed his/her opinion about the self-development of the diary writing activity;

When my teacher was writing a diary, we were writing on paper what we learnt every day. That's how I was improving myself (LD_1)

with these sentences. The student coded LD_6 for the repetition of the diary writing activity;

When we switched to a topic, I was always repeating it and I was ready for the next day because we stopped on the same topic for two or three days (LD_6)

While the student with the code D_5 stated that the diary writing activity provided fun;

It had a nice effect. It's fun (D_5)

with these words. Finally, the student coded D_3 expressed his/her opinion on the permanence of the diary writing activity;

When I write and read the topics, it stays in my mind more (D_3)

expressed as follows.

The students in the DG and LDG who used the diary writing activity were asked the question "*Did you encounter difficulties in the* diary *writing activity? If so, what are these difficulties*?" and the findings of the students' answers to this question are presented in Table 8.

Table 8. Difficulties of the diary writing activity

Code	Student	Frequency
Can't keep up with your writing	D_1, LD_1, LD_6	3
Did not meet	D_2, D_3, D_4, D_5, LD_2, LD_3, LD_4, LD_5	8

When Table 8 is analyzed, it is seen that 3 students stated that they had difficulty in completing the diary writing activity, while 8 students did not encounter any difficulties.

The student with the code LD_1 stated that the diary writing activity was difficult to complete;

I faced difficulties sometimes. While I was thinking about what I was going to write, time was passing and sometimes I could not complete all what I was going to write (LD_1)

While the student with the code D_4 stated that he did not encounter any difficulties while writing a diary,

No, I have not (D_4)

in a statement.

DISCUSSION AND CONCLUSION

As a result of the analyses on the effect of diary and letter writing activities on academic achievement, it was determined that there was a significant difference in the post-test scores of the experimental and control groups in favor of the experimental groups. Therefore, it can be said that diary and letter writing activities, which are writing to learn activities, are effective in increasing academic achievement. This result obtained from the study is similar to the results of the studies examining the academic achievement of writing activities for learning in mathematics teaching (Ayyıldız, 2010; Bell & Bell, 1985; Bicer et al, 2013; Borasi & Rose, 1989; Cisero, 2006; Çontay & Duatepe-Paksu, 2018; Frenkel, 2004; Karadağ & Öztürk, 2022; Kasa, 2009; Klishis, 2003; Raquid & Litao, 2023; Roskin, 2010; Stack, 1998; Teuscher, Kulinna & Crooker, 2015; Uslu, 2009; Ünlü & Soylu, 2017; Van Dijk et al, 2022; Yıldırım, 2016; Yılmaz, 2014). For example, Ünlü and Soylu (2017) stated that different learning-oriented writing activities used in secondary school mathematics course increased student achievement, attitude and metacognitions. In another study, Karadağ and Öztürk (2022) stated that writing letters and diaries, which are writing to learn activities, increased 7th grade students' achievement in the subject of ratio, proportion and percentages. Yılmaz (2014) stated that diary writing and various writing activities applied to secondary school students in algebra teaching increased student achievement. On the other hand, Kasa (2009) applied different writing activities, including letter and diary writing activities, in his study with primary school students and concluded that the application increased students' mathematics achievement and positively affected their attitude towards the course. Kesebir (2019) concluded that mathematics diaries kept by fourth grade students increased achievement, metacognition and motivation. In another study, Ayyıldız (2010) concluded that there was a significant difference between the post-test scores of the experimental group and the control group students in favor of the experimental group. This result showed that learning diaries, which enable students to be mentally active, are successful in increasing conceptual development. In addition, Yıldırım (2016) concluded that the letter and diary writing activities applied in teaching algebraic expressions to 6th grade students increased student achievement and that the activities were not superior to each other. This result coincides with the research result.

On the other hand, there are studies in the literature that differ from the results of this study. For example, Jurdak and Zein (1998) concluded that writing to learn activities had no effect on achievement, but had positive effects such as providing conceptual understanding and increasing communication. Since writing to learn activities enable students to construct the knowledge they have learned and express it in their own words, they may not be directly reflected in exam success or grades, since success criteria are often based on memorization and standardized test performance. However, writing to learn activities can be said to contribute to deeper learning in the long run as they strengthen conceptual understanding and increase students' engagement with knowledge. Strengthening communication can be explained by enabling students to express their thoughts more clearly and effectively.

When the interviews with the students in the experimental groups were evaluated after the application of the post-test in the study, the students who used the letter writing activity mentioned the positive effects of this activity such as providing a better understanding of the subject, repeating the subject, providing permanent learning, providing cooperation, transferring emotions, and increasing attention. On the other hand, students who used diary writing activities stated that diary writing had positive effects such as providing a better understanding of the subject, providing permanent learning, and repetition. There are studies with similar results in the literature (Aktepe, 2020; Çontay, 2012; Köksal, 2019; Öztürk & Demiroğlu-Çiçek, 2024; Sample, 1998; Tekin-Aytaş & Uğurel, 2016). Rivard and Straw (2000) stated that letter writing activity provides long-term retention of scientific knowledge. Again, according to Mason and Boscolo (2000), these activities facilitate students' conceptual changes and ensure that the relevant concepts are successfully and permanently structured by students. In addition, Aktepe (2020) stated in his study that the students learnt the subject better, thought that they helped someone and repeated the subject. Tekin-Aytaş and Uğurel (2016), on the other hand, stated that students revised the subject with writing activities and realized their deficiencies.

All of the students who wrote diaries and letters expressed positive opinions about the comprehension of the learning writing activities used and stated that they understood better by writing (Atasoy, 2005; Ay, 2018; Çontay, 2012; Nahrang & Peterson, 1986; Öztürk, Kaymakoğlu & Demiroğlu-Çiçek, 2022; Sample, 1998; Yılmaz, 2014). Köksal (2019) reached similar student opinions in his study and stated that writing to learn activities provide learning the subject in detail, easy understanding, reinforcement, retention of the subject in memory and realizing the unlearned parts.

Regarding the difficulties of the writing to learn activities used in the study, the students who used the letter writing activity stated that they had difficulty in expressing themselves, remembering the subject and following the spelling rules. Very few of the

students who used diary writing activities stated that they had difficulty. Çontay (2012) and Sample (1998) stated in their studies that the majority did not have difficulty in writing to learn activities. In this context, diary and letter writing activities can be used to increase comprehension in mathematics lessons. In addition, diary and letter writing activities provide important opportunities to evaluate students' learning by determining their comprehension and misconceptions and to provide feedback to them.

RECOMMENDATIONS

Diary and letter writing activities can be used to increase comprehension in mathematics lessons. In addition, diary and letter writing activities provide important opportunities to evaluate students' learning by determining their comprehension and misconceptions and to provide feedback to them.

Considering that only diary and letter writing activities were used in this study, it should not be forgotten that the results of studies in which other writing activities (poster preparation, story, poem, etc.) were used can also make an important contribution to the literature.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

Funding

The authors received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The authors contributed equally to all processes of the article. The authors have read and approved the final version of the article.

Ethics Committee Approval Information

The ethics committee document of this study was approved by the decision of Kırıkkale University Social and Human Research Ethics Committee dated 18.03.2022 and numbered 03.

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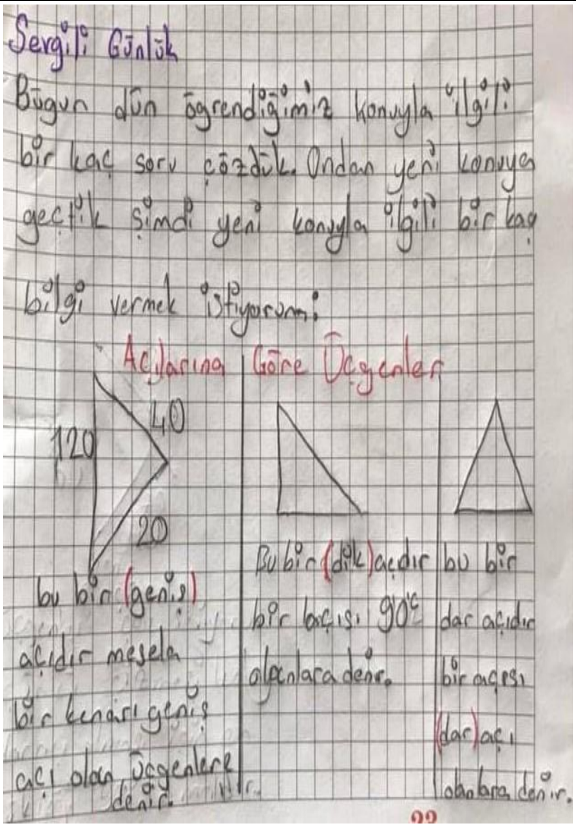
APPENDIX

Examples of Diaries Written by Students


Sevgili Günlük

Bugün dün öğrendiğimiz konuyla ilgili bir kaç soru çözdük. Ondan yeni konuya geçtik şimdi yeni konuyla ilgili bir kaç bilgi vermek istiyorum:

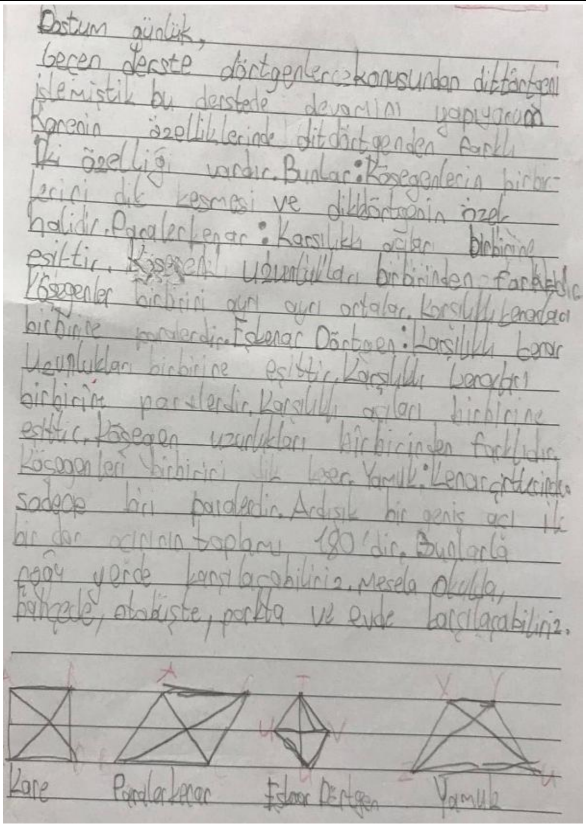
Açılarına Göre Üçgenler

120 40 20

bu bir (geniş) açıdır mesela bir kenarı geniş açı olan üçgenlere denir.

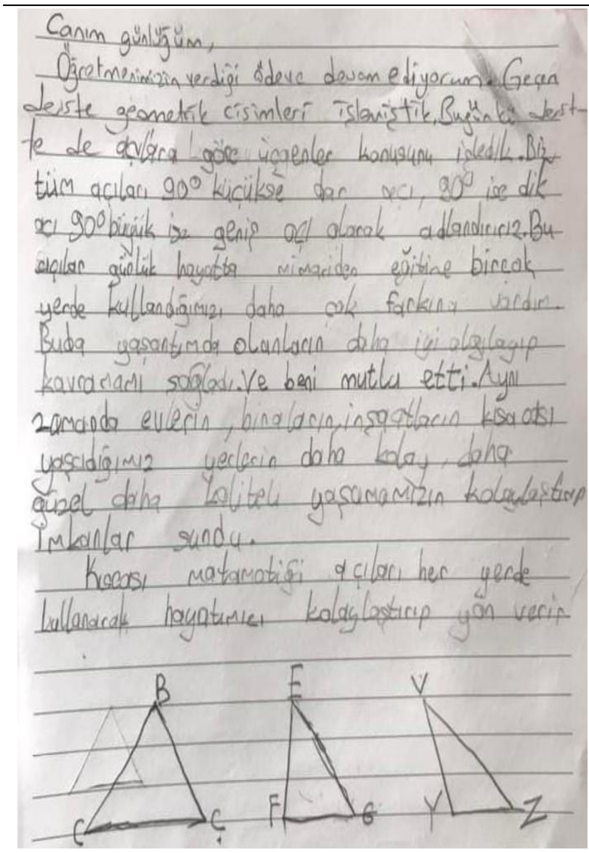
Bu bir (dik) açıdır bir açısı 90° olanlara denir.

bu bir dar açıdır bir açısı (dar) açı olanlara denir.


Dostum günlük,

Geçen derste dörtgenler konusundan dikdörtgeni işlemiştik bu derste devamını yapıyoruz. Karenin özelliklerinde dikdörtgenden farklı iki özelliği vardır. Bunlar: Köşegenlerin birbirlerini dik kesmesi ve dikdörtgenin özel halidir. Paralelkenar: Karşılıklı açıları birbirine eşittir. Köşegen uzunlukları birbirinden farklıdır. Köşegenler birbirini ayrı ayrı ortalar. Karşılıklı kenarları birbirine paralerdir. Eşkenar Dörtgen: Karşılıklı kenar uzunlukları birbirine eşittir. Karşılıklı kenarları birbirine paralerdir. Karşılıklı açıları birbirine eşittir. Köşegen uzunlukları birbirinden farklıdır. Köşegenleri birbirini dik keser. Yamuk: Kenar çiftlerinden sadece biri paralerdir. Ardışık bir geniş açı ile bir dar açının toplamı 180'dir. Bunlarla çoğu yerde karşılaşabiliriz. Mesela okulda, bahçede, otobüste, parkta ve evde karşılaşabiliriz.

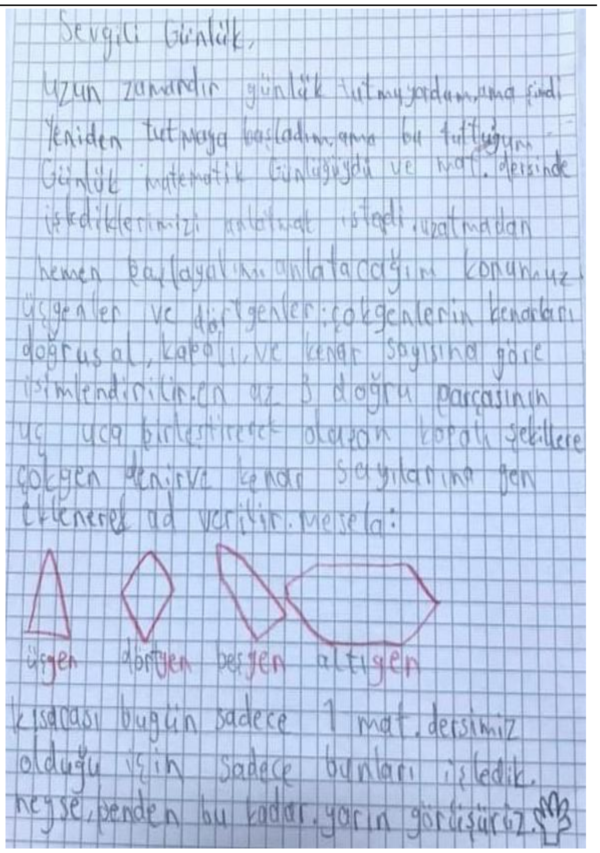
Kare Paralelkenar Eşkenar Dörtgen Yamuk


Canım günlüğüm,

Öğretmenimizin verdiği ödeve devam ediyorum. Geçen derste geometrik cisimleri işlemiştik. Bugünkü derste de açılara göre üçgenler konusunu işledik. Biz tüm açıları 90° küçükse dar açı, 90° ise dik açı 90° büyük ise geniş açı olarak adlandırırız. Bu açılar günlük hayatta mimariden eğitime birçok yerde kullandığımızı daha çok farkına vardım. Bu da yaşantımda olanları daha iyi algılayıp kavramamı sağladı. Ve beni mutlu etti. Aynı zamanda evlerin, binaların, inşaatların kısacası yaşadığımız yerlerin daha kolay, daha güzel daha kaliteli yaşamamızın kolaylaştırıp imkanlar sundu.

Kısacası matematiği açıları her yerde kullanarak hayatımızı kolaylaştırıp yön verir.

B C Ç E F G V Y Z

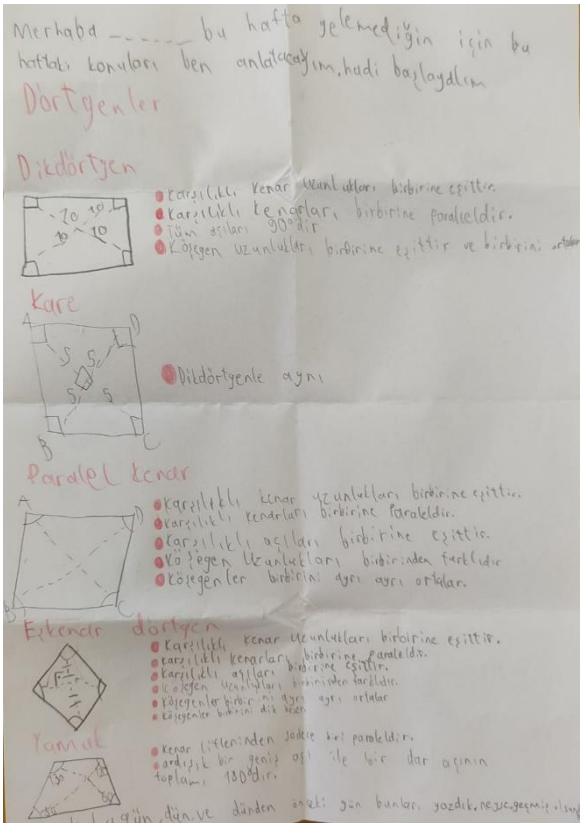

Sevgili Günlük,

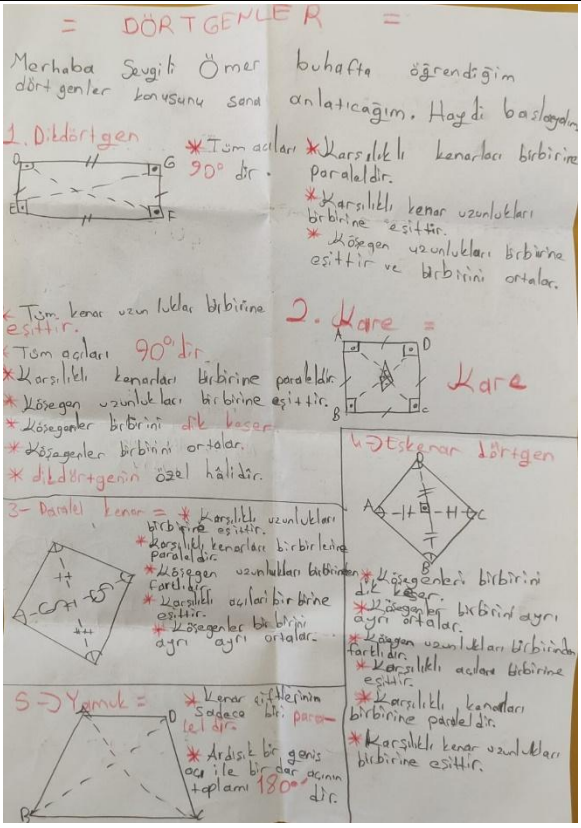
Uzun zamandır günlük tutmuyordum, ama şimdi yeniden tutmaya başladım ama bu tuttuğum günlük matematik günlüğüydü ve mat. dersinde işlediklerimizi anlatmak istedim. Uzatmadan hemen başlayalım. Anlatacağım konumuz üçgenler ve dörtgenler: Çokgenlerin kenarları doğrusal, kapalı ve kenar sayısına göre isimlendirilir. En az 3 doğru parçasının uç uca birleştirilerek oluşan kapalı şekillere çokgen denir. Ve kenar sayılarına gen eklenerek ad verilir. Mesela:

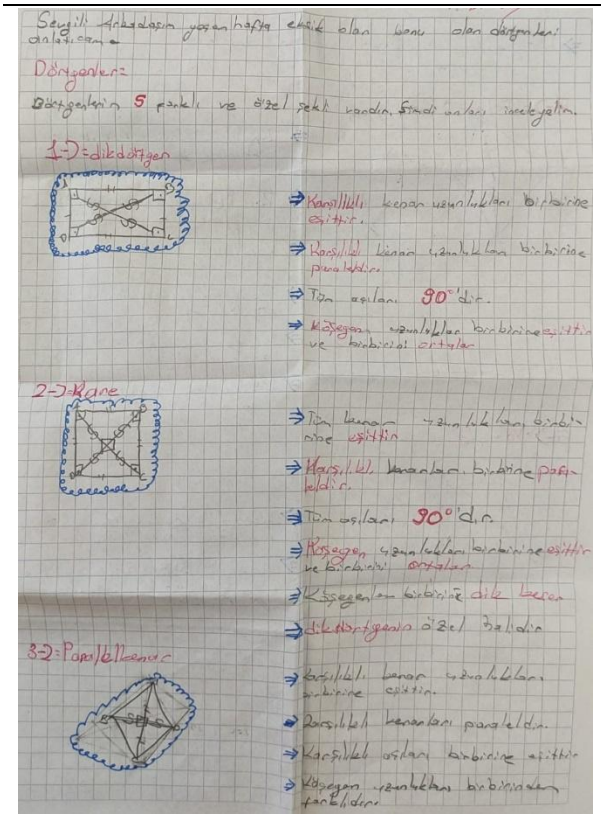
üçgen dörtgen beşgen altıgen

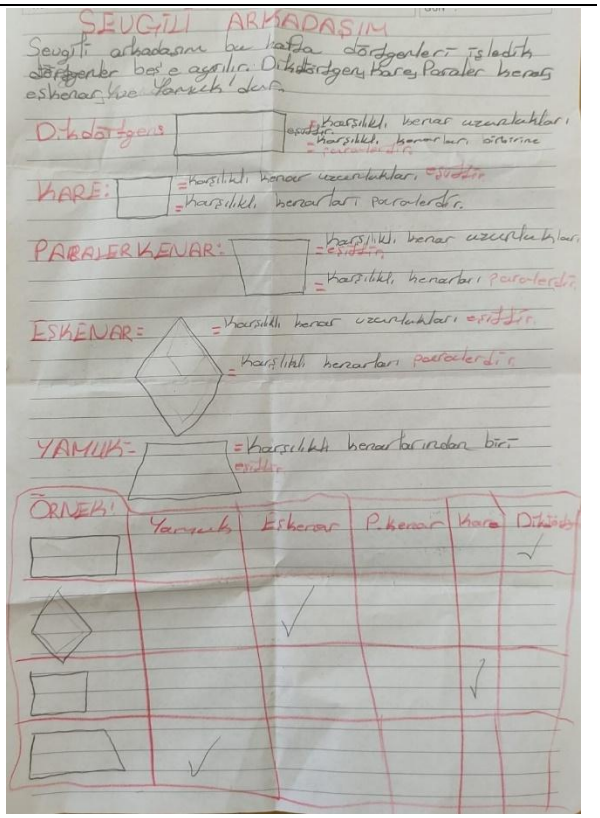
Kısacası bugün sadece 1 mat. dersimiz olduğu için sadece bunları işledik. Neyse, benden bu kadar. Yarın görüşürüz.

Examples of Letters Written by Students









Kastamonu Education Journal, 2025, Vol. 33, No:2, 253-262
doi: 10.24106/kefdergi.1682935

| Research Article / Araştırma Makalesi |

Mathematics Anxiety Among Primary School Teachers: Scale Adaptation and Anxiety Level Determination Study

Sınıf Öğretmenlerinin Matematik Kaygısı: Ölçek Uyarlama ve Kaygı Düzeyi Belirleme Çalışması

Eyüp BOZKURT[1], **Deniz KILIÇ**[2]

Keywords

1. Mathematics anxiety
2. Scale adaptation
3. Primary school teachers
4. Anxiety level

Anahtar Kelimeler

1. Matematik kaygısı
2. Ölçek uyarlama
3. Sınıf öğretmenleri
4. Kaygı düzeyi

Received/Başvuru Tarihi
14.09.2024

Accepted / Kabul Tarihi
19.02.2025

Abstract

Purpose: This study aims to adapt a scale to measure the mathematics anxiety of primary school teachers and to determine their anxiety levels. Mathematics anxiety can significantly impact teachers' professional competencies and their effects on students. Therefore, accurately determining teachers' anxiety levels and developing strategies to reduce this anxiety is of great importance.

Design/Methodology/Approach: The research used a cross-sectional survey design and was carried out with 300 primary school teachers from various regions across Turkey during the spring term of 2023. Data were collected through an online survey, and validity and reliability analyses were conducted on the adapted scale. Expert opinions were sought for the linguistic and cultural adaptation of the scale, a pilot study was conducted, and then the main study was carried out.

Findings: The findings obtained during the scale adaptation process indicate that the scale is valid and reliable. The mathematics anxiety levels of teachers show significant differences according to variables such as gender, age, and professional experience. Notably, it was found that female teachers have higher levels of mathematics anxiety compared to male teachers. Additionally, teachers with less professional experience were found to have higher anxiety levels.

Highlights: Mathematics anxiety among primary school teachers is a crucial factor that should be considered when developing educational policies and teacher training programs. Strategies and support programs to reduce mathematics anxiety are recommended. Teacher training programs should include methods and techniques to reduce mathematics anxiety.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, sınıf öğretmenlerinin matematik kaygısını ölçmek için bir ölçek uyarlamak ve öğretmenlerin kaygı düzeylerini belirlemektir. Matematik kaygısı, öğretmenlerin mesleki yeterliliklerini ve öğrencilere olan etkilerini önemli ölçüde etkileyebilir. Bu nedenle, öğretmenlerin kaygı düzeylerinin doğru bir şekilde belirlenmesi ve bu kaygıyı azaltmaya yönelik stratejilerin geliştirilmesi büyük önem taşımaktadır.

Materyal ve Yöntem: Araştırmada kesitsel tarama modeli kullanılmıştır. Çalışma, 2023 bahar döneminde Türkiye'nin farklı bölgelerinden 300 sınıf öğretmeni üzerinde gerçekleştirilmiştir. Veriler, çevrimiçi anket yoluyla toplanmış ve uyarlanan ölçeğin geçerlik ve güvenirlik analizleri yapılmıştır. Ölçeğin dilsel ve kültürel uyarlaması için uzman görüşlerine başvurulmuş, pilot çalışma gerçekleştirilmiş ve sonrasında ana çalışma uygulanmıştır.

Bulgular: Ölçek uyarlama sürecinde elde edilen bulgular, ölçeğin geçerli ve güvenilir olduğunu göstermektedir. Öğretmenlerin matematik kaygı düzeyleri cinsiyet, yaş ve mesleki deneyim değişkenlerine göre anlamlı farklılıklar göstermektedir. Özellikle, kadın öğretmenlerin matematik kaygı düzeylerinin erkek öğretmenlere göre daha yüksek olduğu belirlenmiştir. Ayrıca, mesleki deneyimi az olan öğretmenlerin kaygı düzeylerinin daha yüksek olduğu tespit edilmiştir.

Önemli Vurgular: Sınıf öğretmenlerinin matematik kaygısı, eğitim politikaları ve öğretmen eğitim programları geliştirilirken dikkate alınması gereken önemli bir faktördür. Matematik kaygısını azaltmaya yönelik stratejiler ve destek programları önerilmektedir. Öğretmen eğitim programlarında, matematik kaygısını azaltacak yöntem ve tekniklerin yer alması gerekmektedir.

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Citation/Alıntı: Bozkurt, Ü., & Kılıç, D. (2025). Mathematics Anxiety Among Primary School Teachers: Scale Adaptation and Anxiety Level Determination Study, *Kastamonu Education Journal, 33*(2), 253-262. doi: 10.24106/kefdergi.1682935

INTRODUCTION

Anxiety makes a person feel that something bad might happen (Işık, 1996). According to Cüceloğlu (1991), anxiety arises from withdrawal of support, expectation of negative outcomes, internal conflict, and uncertainty. Anxiety can be normal or pathological; situational anxiety is short and intense, while trait anxiety lasts longer but is less intense. Factors affecting anxiety are environmental, individual, and situational. The most used anxiety scales are the 'Manifest Anxiety Scale (MAS)' and the 'State Trait Anxiety Inventory' (Karagüven, 1999).

Mathematics is an essential discipline used to solve everyday problems (Aksu, 2008). A student's mathematics achievement is influenced by intelligence, developmental level, attitude, self-efficacy, and family support (Çağırgan Gülten and Derelioğlu, 2006). Attitudes towards mathematics by both students and teachers are influenced by factors such as gender, learning environment, family, and teacher support (Chappell, 2003). Teachers' attitudes directly affect students' attitudes towards mathematics (Aiken, 1970). Positive teacher attitudes help students develop positive attitudes towards mathematics (Kulm, 1980).

Mathematics anxiety can create negative emotions in students and affect their performance (Lim and Chapman, 2015). The causes of anxiety are personal, personality-based, and situational factors. Factors stemming from the student and their environment, including their own and their family's attitudes towards mathematics, are significant (Keçeci, 2011). To treat mathematics anxiety, psychological counseling and mathematics skill development techniques are used (Elman, 1991). Teachers' attitudes directly affect students' mathematics anxiety; supportive and encouraging teachers can reduce anxiety (Sloan, Daane, and Giesen, 2002).

In the literature, the number of current scales measuring anxiety is limited (Üldaş, 2005; Akçakın, Cebesoy, and İnel, 2015). Thus, the study aims to adapt the "Math Anxiety Scale for Teachers (MAST)," created by Colleen M. Ganley and her team in 2019, into Turkish. It will also explore the connection between primary school teachers' anxiety about teaching math and their general math anxiety in Elazığ. Additionally, the study will assess whether factors such as age, gender, years of experience, grade level, and class size lead to significant differences in both teaching math anxiety and general math anxiety.

Purpose and Originality of the Research

Anxiety is often described as a feeling of unease that arises due to an unknown reason or conflict (Aydın, Delice, Dilmaç, and Ertekin, 2009). This unease can manifest as mathematics anxiety when it relates to mathematics. Mathematics anxiety can lead students to develop negative attitudes toward situations requiring mathematical operations (Ma and Xu, 2004). This type of anxiety typically emerges in students during their primary school years because of negative experiences (Harper et al., 1998). For primary school teachers to positively influence students' levels of mathematics anxiety, they must first maintain a positive attitude towards mathematics themselves. Teachers can foster positive attitudes in students, which can enhance their mathematical performance (Yücel and Koç, 2011). Therefore, it is crucial to assess and address teachers' levels of mathematics anxiety (Üldaş, 2005). The foundation of this research problem lies in the absence of a scale capable of measuring both general math anxiety and anxiety specifically related to teaching math. Consequently, the following hypotheses will be investigated:

H1: There is a statistically significant relationship between primary school teachers' mathematics teaching anxiety and their general mathematics anxiety.

H2: There is a statistically significant difference between primary school teachers' mathematics anxiety and gender.

H3: There is a statistically significant difference between primary school teachers' mathematics anxiety and age.

H4: There is a statistically significant difference between primary school teachers' mathematics anxiety and years of service.

H5: There is a statistically significant difference between primary school teachers' mathematics anxiety and grade level taught.

H6: There is a statistically significant difference between primary school teachers' mathematics anxiety and the number of students in the class.

Teacher anxiety can impact their students, especially in primary school, where the foundations of anxiety are established. High teacher anxiety can negatively affect students, leading to mathematics anxiety. Identifying the level of this anxiety with an up-to date scale is crucial. This study uses a new scale from 2019, addressing the gap in current literature where most scales are outdated. Moreover, the study fills a significant gap by using a two-factor scale those measures both general and mathematics teaching anxiety. The scale's practical usability due to its optimal number of items also adds to the study's uniqueness and importance.

METHOD/MATERIALS

In this study, the “Math Anxiety Scale for Teachers (MAST)” developed by Ganley et al. (2019) was adapted into Turkish to determine the mathematics anxiety levels of primary school teachers. The scale was translated into Turkish using the back-translation technique (Hançer, 2003). Additionally, the general survey model, one of the quantitative research methods, was used to determine the mathematics anxiety levels of primary school teachers (Karasar, 2008).

Sample of the Research

The study's population includes primary school teachers employed in Elâzığ. The sample comprises 381 teachers chosen through convenience sampling. (Yıldırım and Şimşek, 2018). From the sample, data from 154 teachers were used in DFA analyses, and data from 227 teachers were used in other analyses (Kline, 1994; Pituch and Stevens, 2016). The back-translation technique was used for translating the scale into Turkish (Looman and Farrag, 2009). The scale was first translated into Turkish by three experts proficient in both mathematics and English. It was then translated back into English by another set of experts, and the original and back-translated versions were compared. The comprehensibility of the adapted scale was tested on 30 primary school teachers.

Data Collection Tool

Data were collected using a survey technique. The survey consists of two parts: a personal information form to gather demographic details of the participants and the scale to determine the general mathematics anxiety and mathematics teaching anxiety of the teachers. The "Math Anxiety Scale for Teachers (MAST)" developed by Ganley et al. (2019) was used. The scale comprises two factors: mathematics teaching anxiety and general mathematics anxiety, with a total of 15 items, structured on a 5-point Likert scale (Ganley et al., 2019)..

Data Analysis

Data were organized in Microsoft Excel and transferred to SPSS 29.0 for analysis. Skewness and Kurtosis tests were used to check the normal distribution of the data. Confirmatory Factor Analysis (CFA) was conducted using AMOS 22 to check the fit indices. Categorical data were analyzed using frequency and percentage values, while numerical data were analyzed using mean and standard deviation values. The "Independent Sample T-Test" was employed to compare two distinct groups, while One-Way ANOVA or Kruskal-Wallis tests were utilized for comparing more than two groups. The "Pearson Correlation Test" was used to assess the relationship between two numerical variables. The significance level for all analyses was established at $p<0.05$.

FINDINGS

Colleen M. Ganley et al. (2019) developed the original scale named "Math Anxiety Scale for Teachers (MAST)". This section details the process of adapting the scale into Turkish and presents the findings of the study.

Findings Related to Confirmatory Factor Analyses

Using modification indices to improve the goodness of fit values in confirmatory factor analysis is recommended (Jöreskog and Sörbom, 1993: 127; Whittaker, 2016: 658). This involves establishing covariance links between error terms, reducing the chi-square value, and improving model fit indices. Following the suggested indices, covariance relationships were established between error terms of theoretically related items. After applying three recommended modifications—e1-e2 (0.26), e2-e4 (0.24), and e2-e3 (0.28) —improvements in model fit were observed. The confirmatory factor analysis, with two latent and 15 observed variables, was validated. Detailed values are discussed under goodness of fit findings. Table 1 presents findings on standardized/unstandardized factor loadings, standard error, t values, and significance levels.

Table 1. CFA Results for the Measurement Model

		β0[1]	β1[2]	S.E.[3]	t	p
Item 8	GMA[4]	0.687	0.915	0.079	11.602	***
Item 7	GMA	0.643	0.976	0.104	9.375	***
Item 6	GMA	0.739	0.989	0.092	10.790	***
Item 5	GMA	0.653	0.841	0.088	9.524	***
Item 4	GMA	0.789	0.975	0.085	11.519	***
Item 3	GMA	0.742	0.938	0.087	10.826	***
Item 2	GMA	0.851	0.991	0.080	12.425	***
Item 15	MTA[5]	0.788	1.000			
Item 14	MTA	0.824	1.042	0.076	13.657	***
Item 13	MTA	0.712	0.817	0.072	11.373	***
Item 12	MTA	0.707	1.015	0.090	11.272	***
Item 11	MTA	0.736	0.969	0.082	11.843	***
Item 10	MTA	0.806	1.010	0.076	13.258	***
Item 1	GMA	0.704	0.847	0.082	10.272	***
Item 9	GMA	0.716	1.000			

[1] Standardized factor loading [2] Unstandardized factor loading [3] Standard Error [4] General Mathematics Anxiety [5] Mathematics Teaching Anxiety

Upon examining Table 1, it was found that the correlations between variables are significant. Additionally, the standardized factor loadings of the items are observed to be above 0.30.

Findings on the Goodness of Fit Values of the Structural Model

When examining the goodness of fit values of the structural model, the significance level of the model and whether the structure needs improvement were evaluated.

Table 2. Structural Model Values and Acceptable Fit

	Structural Model Values	Acceptable Fit
χ2/df*	2,707	2d≤ χ2/sd ≤ 3
RMSEA**	0,087	0,05 <RMSEA ≤ 0,10
CFI***	0,932	0,90 ≤ CFI ≤ 0,95
IFI***	0,908	0,90 ≤ IFI ≤ 0,95
IFI***	0,908	0,90 ≤ IFI ≤ 0,95
TLI***	0,917	0,90 ≤ TLI ≤ 0,95
NFI***	0,912	0,90 ≤ NFI ≤ 0,95
GFI***	0,883	0,90 ≤ GFI ≤ 0,95
SRMR**	0,043	0,5 ≤ SRMR ≤ 0,10
χ2: 232,831; df:86; p<0,001		

* Kline, 2011 16

** Browne & Cudeck, 1993 17

*** Baumgartner & Homburg, 1996; Bentler, 1980; Bentler & Bonett, 1980; Marsh, Hau, Artelt, Baumert & Peschar, 2006

The results indicate that the structural equation model is significant at the p <0.001 level based on CFA analysis. The goodness of fit values confirm the structure's validity (χ^2 = 232.831 (df) = 86; p <0.001; χ^2/df = 2.707; CFI = 0.932; GFI = 0.883; NFI = 0.912; IFI = 0.908; TLI = 0.917; RMSEA = 0.087; SRMR = 0.0437), with all values except GFI within the acceptable range. The 15 items of the scale relate to a two-dimensional structure. Fornell and Larcker's (1981) AVE and CR values were calculated, both of which are above the acceptable thresholds for convergent validity (for GMA: AVE = 0.5287, CR = 0.9093; for MTA: AVE = 0.5847, CR = 0.8938).

Findings on the Assumption of Normality and Reliability

Table 5 presents the analysis results regarding whether the data is normally distributed and how reliable it is. According to Tabachnick and Fidell (2013), data is considered to come from a normal distribution if the skewness and kurtosis values are between -1.5 and +1.5.

Table 3. Normality Assumption Analysis and Reliability Analysis

Scale	n	Mean	SD	Skewness	Kurtosis	Cronbach's Alpha
General Mathematics Anxiety	227	17.41	7.050	0.822	-0.242	0.911
Mathematics Teaching Anxiety	227	8.42	3.512	0.751	0.143	0.891
Mathematics Anxiety Scale	227	25.83	9.952	0.724	-0.242	0.942

Upon examining the Skewness and Kurtosis values, it is determined that the subscales of General Mathematics Anxiety and Mathematics Teaching Anxiety, as well as the Mathematics Anxiety Scale, follow a normal distribution. The scale's reliability is evaluated using the Cronbach's Alpha coefficient. A Cronbach's Alpha value greater than 0.70 suggests that the scale is considered reliable. The results demonstrate that the General Mathematics Anxiety, Mathematics Teaching Anxiety subscales, and the Mathematics Anxiety Scale are reliable.

Findings Related to Sociodemographic Information

A dataset of 154 individuals from the study's sample of 381 was used for CFA analyses. The remaining dataset of 227 individuals was used for other analyses. The findings related to the sociodemographic information of the current sample of 227 individuals are presented in Table 4 below.

Table 4. Sociodemographic Information Table

Variables	Group	n	Percent (%)
Years	22-32 Years	134	59
	33-41 Years	47	20,7
	42-51 Years	21	9,3
	52 Years and Above	25	11
Grade	1	71	31,3
	2	36	15,9
	3	51	22,5
	4	69	30,4
Average Number of Students in the Class	20 People and Below	66	29,1
	21-29 People	87	38,3
	30 People and Above	74	32,6

72.2% of the participants are women, and 59% are between the ages of 22 and 32. 37.4% of the participants have a tenure of 1-5 years. 31.3% of the participants are in the first grade. Additionally, 38.3% of the participants report that the average number of students in their class is between 21 and 29.

T-Test Findings for the Gender Variable

The T-test findings for the gender variable are presented in Table 5. An independent samples t-test was conducted to determine if there are any differences between female and male participants in terms of their general mathematics anxiety, mathematics teaching anxiety subscales, and total scores on the mathematics anxiety scale.

Table 5. Gender Variable T-Test Table

Scale	Group	n	Mean	SD	t	p
General Mathematics Anxiety	Female	164	17.32	6.93	-0.895	0.372
	Male	63	18.22	6.53		
Mathematics Teaching Anxiety	Female	164	12.23	5.16	0.627	0.531
	Male	63	11.75	5.16		
Mathematics Anxiety Scale	Female	164	29.54	11.54	-0.251	0.802
	Male	63	29.97	11.13		

*p<0,05

An independent samples t-test was used to determine if there were any differences between male and female participants in their mathematics teaching anxiety subscales, general mathematics anxiety, and total scores on the mathematics anxiety scale. The results indicated no statistically significant differences between genders in these measures (p>0.05). The scores for general mathematics anxiety, mathematics teaching anxiety subscales, and the mathematics anxiety scale did not vary by gender.

One-Way ANOVA Analysis Based on Class, Age, and Average Number of Students in the Class

The findings regarding the answer to the question “What are the main factors affecting organizational commitment in theses?” addressed in the sixth sub-problem are given in Table 4. As seen in Table 3, only 375 theses of relational screening type were considered.

Table 6. Gender Variable T-Test Table

Variables	Scale	Group	n	Mean	s	F	p	Difference
Age	General Mathematics Anxiety	22-32 Years	134	17.60	7.04	1.475	0.231	
		33-41 Years	47	16.32	6.00			
		42 Years and Above	46	18.74	6.87			
	Mathematics Teaching Anxiety	22-32 Years	134	12.42	5.52	1.454	0.236	
		33-41 Years	47	10.96	4.27			
		42 Years and Above	46	12.30	4.77			
	Mathematics Anxiety Scale	22-32 Years	134	30.02	11.94	1.438	0.240	
		33-41 Years	47	27.28	9.59			
		42 Years and Above	46	31.04	11.39			
Class	General Mathematics Anxiety	1	71	17.51	6.90	1.537	0.206	
		2	36	15.47	5.54			
		3	51	18.35	6.63			
		4	69	18.14	7.36			
	Mathematics Teaching Anxiety	1	71	12.13	5.18	1.883	0.133	
		2	36	10.44	4.54			
		3	51	13.08	5.34			
		4	69	12.19	5.17			
	Mathematics Anxiety Scale	1	71	29.63	11.58	1.802	0.148	
		2	36	25.92	9.05			
		3	51	31.43	11.17			
		4	69	30.33	12.25			
Average Number of Students in the Class	General Mathematics Anxiety	20 and Below	66	16.68	6.18	0.904	0.406	
		21-29 People	87	18.17	7.45			
		30 and Below	74	17.65	6.58			
	Mathematics Teaching Anxiety	20 and Below	66	11.80	4.70	0.171	0.843	
		21-29 People	87	12.13	5.14			
		30 and Below	74	12.31	5.58			
	Mathematics Teaching Anxiety	20 and Below	66	28.48	10.43	0.510	0.601	
		21-29 People	87	30.30	12.09			
		30 and Below	74	29.96	11.48			

There were no statistically significant differences found between class levels and the total scores for general mathematics anxiety, mathematics teaching anxiety, and the mathematics anxiety scale ($p>0.05$). This indicates that the scores for general mathematics anxiety, the subscales of mathematics teaching anxiety, and the total scores on the mathematics anxiety scale do not vary by class level.

Similarly, the analysis showed no statistically significant differences between the average number of students in the class and the total scores for general mathematics anxiety, mathematics teaching anxiety, and the mathematics anxiety scale ($p>0.05$). This suggests that the scores for these measures do not differ based on the average number of students in the class.

Furthermore, there were no statistically significant differences between age groups and the total scores for general mathematics anxiety, mathematics teaching anxiety, and the mathematics anxiety scale ($p>0.05$). The scores for general mathematics anxiety, the subscales of mathematics teaching anxiety, and the total mathematics anxiety scale do not vary by age group.

Kruskal-Wallis H Test Findings Related to the Tenure Variable

The findings of the Kruskal-Wallis H test related to the tenure variable are presented in Table 7.

Table 7. Kruskal-Wallis H Analysis for the Tenure Variable

Scale	Group	n	Mean	SD	H	p	η²
General Mathematics Anxiety	1-5 Years	85	19.78	7.55	24.869	<0.001*	0.120
	6-10 Years	63	14.52	4.64			
	11-15 Years	26	15.62	6.24			
	16-20 Years	20	20.45	6.39			
	20 and Above	33	17.48	6.55			
Mathematics Teaching Anxiety	1-5 Years	85	13.88	5.76	18.350	<0.001*	0.089
	6-10 Years	63	10.29	4.30			
	11-15 Years	26	11.00	4.18			
	16-20 Years	20	12.75	4.27			
	20 and Above	33	11.39	4.81			
Mathematics Anxiety Scale	1-5 Years	85	33.66	12.79	23.336	<0.001*	0.114
	6-10 Years	63	24.81	8.05			
	11-15 Years	26	26.62	9.98			
	16-20 Years	20	33.20	9.71			
	20 and Above	33	28.88	11.19			

*p<0.05

The general mathematics anxiety scores significantly differ according to the tenure variable groups (p<0.001). Posthoc analysis indicates that individuals with 1-5 years and 16-20 years of tenure have significantly higher average general mathematics anxiety scores compared to those with 6-10 years of tenure. The effect size, eta squared (η^2), is 0.12, indicating a small effect.

Similarly, mathematics teaching anxiety scores also significantly differ according to the tenure variable groups (p<0.001). Posthoc analysis shows that individuals with 1-5 years and 16-20 years of tenure have significantly higher average mathematics teaching anxiety scores compared to those with 6-10 years of tenure. The effect size, eta squared (η^2), is 0.08, indicating a small effect.

For the mathematics anxiety scale scores, there is a significant difference among the tenure variable groups for overall class teachers (p<0.001). Posthoc analysis reveals that individuals with 1-5 years of tenure have significantly higher average scores compared to those with 6-10 and 11-15 years of tenure. Additionally, individuals with 16-20 years of tenure have significantly higher average scores compared to those with 6-10 years of tenure. The effect size, eta squared (η^2), is 0.11, indicating a small effect.

Table 8. Correlation Analysis

	General Mathematics Anxiety	Mathematics Teaching Anxiety	Mathematics Anxiety Scale
General Mathematics Anxiety	1		
Mathematics Teaching Anxiety	0.747** <0,001	1	
Mathematics Anxiety Scale	0.972** <0,001	0.882** <0,001	1

**p<0,001 *p<0,05

The results of the correlation analysis between general math anxiety, math teaching anxiety, and the overall variables are presented. There is a positive and strong significant relationship between general mathematics anxiety and mathematics teaching anxiety (r=0.747; p=0.000). In other words, as overall mathematics anxiety rises, so does the anxiety relate to teaching mathematics. There is a positive and very strong significant relationship between general mathematics anxiety and the mathematics anxiety scale for classroom teachers (r=0.972; p<0.001). As general mathematics anxiety increases, the total score on the mathematics anxiety scale for classroom teachers also increases.

Additionally, there is a positive and very strong significant relationship between mathematics teaching anxiety and the mathematics anxiety scale for classroom teachers (r=0.882; p<0.001). As mathematics teaching anxiety increases, the total score on the mathematics anxiety scale for classroom teachers also increases.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

The Math Anxiety Scale for Teachers (MAST), developed by Colleen M. Ganley et al. in 2019, was adapted into Turkish to measure the mathematics anxiety of primary school teachers. The study examined the anxiety levels of these teachers based on

various variables. The results and discussions of the research problems are presented, and the findings are compared with similar studies in the literature. Recommendations for researchers are also provided.

The MAST was adapted into Turkish with necessary permissions obtained from Rob Schoen. The scale was translated using back-translation by experts fluent in both English and Turkish. The Turkish version was administered to 30 primary school teachers to assess its clarity, and its validity and reliability were established through statistical analyses. The scale was administered to 154 eachers for confirmatory factor analysis and 227 teachers for additional variable analyses.

Cronbach's alpha reliability analysis was used to assess the reliability of each dimension and sub-dimension of the scale, demonstrating that the Turkish version of the scale is a valid and dependable instrument for measuring mathematics anxiety levels among primary school teachers. Statistical analysis revealed significant differences in mathematics anxiety scores based on gender. Previous studies had mixed findings on this variable, with some reporting no significant differences (Başpınar, 2015; Demir et al., 2016; Üner, 2018; Tabuk, 2018; Deringöl, 2018; Üldaş, 2005; Cooper & Robinson, 1991; Sırmacı, 2007; Olson, 1985; Brush, 1978; Peker & Halat, 2010; Ameen et al., 2002; Marso & Pigge, 1998; Tatar, Zengin, & Kağızmanlı, 2016; Altundal, 2013; Dreger & Aiken, 1957; Ling, 1982; Fee-Fulkerson, 1983) and others identifying higher anxiety levels among female teachers (Zettle & Raines, 2000; Tapia & Marsh, 2000; Alexander & Martray, 1989; Meece, 1981; Karaman & Çil, 2021; Eldemir, 2006; Turan & Asal, 2020; Doruk & Kaplan, 2013; Benson, 1989). This study's results align with some of the literature while differing from others.

It was found that math anxiety scores did not vary significantly by grade level. This finding aligns with the results of several studies. that found no differences based on class level (Başpınar, 2015), but contrasts with others that reported higher anxiety among teachers of higher grade levels due to increased complexity of mathematics topics (Gürbüz & Yıldırım, 2017; Jackson & Leffingwell, 1999).

Likewise, no significant differences were observed in math anxiety scores related to the average number of students in the class. However, some studies have reported increased anxiety in larger classes due to challenges in managing and teaching effectively (Lerkkanen et al., 2014; Miron, 2013; Yıldırım & Gürbüz, 2017; Duban & Küçükyılmaz, 2008; Yılmaz & Altınkurt, 2011). Age was also not a significant factor in mathematics anxiety scores. This result aligns with some studies that found no significant relationship between age and anxiety (Al-Louzi & Salah, 1997; Wiggins, 1984), while others reported that anxiety decreases with age (Erden & Akgul, 2010; Girgin, 1995; Yıldırım, 2013; Richardson & Suinn, 1972; Betz, 1978; Dew et al., 1983; Piyal et al., 2002; Garrosa, 2006; Martinussen et al., 2007).

Tenure showed significant differences in mathematics anxiety scores, with teachers having 1-5 years and 16-20 years of experience showing higher anxiety compared to those with 6-10 years of experience. This is consistent with some studies that found anxiety decreases with increased tenure, suggesting that more experienced teachers develop better coping mechanisms (Yıldırım, 2013; Girgin, 1995).

The research was limited to primary school teachers in Elazığ province and was confined to the scope of the measurement tool and its sub-dimensions.

RECOMMENDATIONS

Researchers are advised to increase the sample size in future studies using the adapted scale, examine the variable of years of service, and explore relationships with different mathematics-related scales. It is also advisable to use both scales together to examine the connection between teacher and student mathematics anxiety and to explore how mathematics anxiety relates to various other factors. It is also suggested to use scales that measure parental mathematics anxiety.

Practitioners are encouraged to use existing scales to determine teachers' levels of mathematics anxiety and to inform them about the negative effects of this anxiety through in-service training. Furthermore, the development of tools to measure mathematics anxiety and studies aimed at understanding the causes of this anxiety are recommended.

Teachers are advised to improve their mathematics knowledge and skills to reduce their mathematics anxiety. Accepting the anxiety and seeking support are considered important steps towards resolving the issue.

Declaration of Conflicting Interests

On behalf of all authors, the corresponding author declares that there is no conflict of interest in this research.

Funding

This research is not funded by any institution or organization.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

This research was conducted following the approval of the Administrative Board of the Institute of Educational Sciences at T.R. Fırat University, dated 03/05/2024 and numbered 869428. The consent to use the scale, which was required for the start of the data collection process, was obtained from the relevant individuals.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 263-275
doi: 10.24106/kefdergi.1683435

| Research Article / Araştırma Makalesi |

Examining The Effectiveness of Methods Used In Teaching Basic Mathematical Concepts To Preschool Children*

Okul Öncesi Çocuklarına Temel Matematik Kavramlarının Öğretiminde Kullanılan Yöntemlerin Etkililiğinin İncelenmesi*

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Keywords

1. Boehm preschool basic concepts test-3
2. Concept teaching
3. Mathematics
4. Preschool

Anahtar Kelimeler

1. Boehm okul öncesi temel kavramlar testi-3
2. Kavram öğretimi
3. Matematik
4. Okul öncesi

Received/Başvuru Tarihi
28.09.2024

Accepted / Kabul Tarihi
19.02.2025

Abstract

Purpose: The aim of this study is to examine the teaching methods that can be used during the instruction of basic mathematical concepts to children in the early childhood period (48-60 months) and to determine which method is the most effective.

Design/Methodology/Approach: The study utilized a quasi-experimental design, which is one of the quantitative research methods. The study sample consisted of 44 children aged 48-60 months who were continuing their education at public kindergartens under the Ministry of National Education (MEB) in Istanbul. The "Boehm Preschool Basic Concepts Test-3 (BÖÖTKT-3)" was used as the data collection tool. Data were analyzed using descriptive and inferential statistics, and the effectiveness of each method was analyzed with a dependent sample t-test. In addition, variances were found to be homogeneously distributed ($p > .05$). Since these assumptions were met, the data were analyzed and compared using ANCOVA.

Findings: The findings from the analyses revealed that the most effective teaching method for teaching basic mathematical concepts in early childhood was the music-based method, among the methods of music-based instruction, drama, and direct instruction.

Highlights: Based on the results obtained from the findings, it is suggested that the music-based teaching method should be actively used in preschool mathematics education in order to increase children's learning outcomes in basic mathematical concepts.

Öz

Çalışmanın amacı: Bu araştırmanın amacı, 48-60 aylık erken çocukluk dönemindeki çocuklara temel matematik kavramlarının öğretimi esnasında kullanılabilecek öğretim yöntemlerinin irdelenmesi, etkili olan yöntemin belirlenmesidir.

Materyal ve Yöntem: Araştırmada nicel araştırma desenlerinden uygun olan yarı deneysel model kullanılmıştır. Çalışmaya İstanbul'da MEB'e bağlı anaokullarında eğitimine devam eden 48-60 aylık 44 çocuk katılmıştır. Araştırmada veri toplama aracı olarak "Boehm Okul Öncesi Temel Kavramlar Testi-3 (BOÖTKT-3)" kullanılmıştır. Veriler betimsel ve kestirimsel istatistik kullanılarak incelenmiş olup her yöntemin etkili olup olmadığı bağımlı örneklem t-testi ile analiz edilmiştir. Bununla beraber varyanslar homojen dağılmıştır ($p>.05$). Bu ön koşullar sağlandığından veriler ANCOVA uygulanarak analiz edilmiş ve karşılaştırılmıştır.

Bulgular: Analizler sonucunda bulunan bulgular neticesinde erken çocukluk döneminde temel matematik kavramlarının öğretiminde müzikle anlatım, drama ve düz anlatım yöntemleri içinden en etkili öğretim yönteminin müzik ile anlatım yöntemi olduğu belirlenmiştir.

Önemli Vurgular: Bulgulardan elde edilen sonuçlar neticesinde çocukların temel matematik kavramlarını öğrenme çıktılarını arttırmak amacıyla, okul öncesi matematik öğretiminde müzikle anlatım yönteminin aktif kullanılması gerektiği düşünülmektedir.

* This study is derived from the first author's master's thesis prepared under the supervision of the second author and presented as an oral presentation at the II. International Dede Korkut Education Research Congress held in Bayburt between 03-05 October 2024.

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Citation/Alıntı: Günaydın, N., & Küçük Demir, B. (2025). Examining The Effectiveness Of Methods Used In Teaching Basic Mathematical Concepts To Preschool Children, *Kastamonu Education Journal, 33*(2), 263-275. doi: 10.24106/kefdergi.1683435

INTRODUCTION

Preschool education forms the foundation for all educational levels. In this context, improving the standards of preschool education is seen as a necessity for overall academic success (Avcı & Dere, 2002). It is expected that the correct academic skills taught during the preschool period will lead to children becoming self-disciplined, enterprising, and investigative individuals who can express their emotions, actively use their abilities, and achieve high academic success (Uyanık & Kandır, 2010). Additionally, preschool experience plays a crucial role in children's future competencies, coping skills, health, and later employment (Melhuish et al., 2008).

Children's first encounter with mathematics does not come through formal education (Akman, 2010). From their earliest months, babies start learning mathematics as part of the explorations they must make in the process of becoming a member of the society in which they live (Anthony & Walshaw, 2009). Children initially use fundamental mathematical concepts in their daily activities, such as games they play, sharing with their families, cooking, completing puzzles, counting, estimating distances, and making music. They are then exposed to formal education in schools. The fun and non-threatening nature of the mathematics education they receive during preschool will significantly influence their ability to learn mathematical concepts (İnan & Erkuş, 2019). Basic concepts learned during the preschool period will play a vital role in acquiring fundamental mathematical skills, such as sorting, classifying, comparing, and one-to-one matching, in later stages of learning (Charlesworth & Lind, 2007). The activities and the adequacy of these activities used in teaching these basic mathematical skills are critical for preparing children for primary education (Çelik, 2019).

Preschool teachers have an important role in supporting and enhancing children's mathematical learning by creating motivating learning environments and providing opportunities for children to engage in activities that integrate mathematics into their daily lives (Bourbour & Masoumi, 2017). Teachers who know how, when, and at what level to present concepts can easily plan activities that are appropriate for the children's level and the subject being taught (İnan & Erkuş, 2019). It is crucial to introduce children to as many methods and materials as possible and to allow them to move freely. Limiting math teaching activities to only paper and pencil can reduce children's interactions with the world around them, making mathematical concepts harder and slower to learn (Yazlık & Öngören, 2018). Some mathematical concepts have multiple meanings in different contexts. Teachers need to understand these meanings and assess whether children have learned the intended meaning of the concept through feedback from the child (Dede & Argün, 2004). There is a widespread belief that access to effective mathematics teaching positively impacts preschool children's life chances, and therefore, teachers providing preschool math education should also receive necessary training (Anthony & Walshaw, 2009; Pekince & Avcı, 2016; Gresham & Burleigh, 2018).

According to Vygotsky, children understand words and form concepts in their minds through three main processes:

1. In the first stage, words are found in a disorganized state within the child's mind as a collection of names for separate objects. In both children and adults, words indicating concrete objects have the same meaning, allowing communication between the child and the adult.

2. In the next stage, thinking begins to form with some confusion. At this stage, the child has formed the meaning of words in their mind, but over time, changes occur in the meanings of these words.

3. The final stage in forming concepts is when the child abstracts and recognizes the common and differing features of concepts, abstracting certain features and combining others (Akman, 2010).

As can be understood from this process, when a child develops concepts, they first recognize the word and learn its features. Then, they try to distinguish between words and work to fix the concept in their minds. In the final stage, they define the concept and try to distinguish its similarities and differences from other concepts. From this perspective, it can be said that learning concepts forms the basis of nearly all other learning.

Basic mathematical concepts need to be known to some extent not only in preschool education but also in later stages. Having sufficient knowledge of basic mathematical concepts will help preschool children in learning other math and science topics in kindergarten and elementary school (Unutkan, 2007). Laying a solid foundation for topics they will learn later will greatly benefit children in their primary education.

Interactions that help children acquire new knowledge and skills, receiving verbal responses and feedback from children, will promote participation in learning and make learning enjoyable (Yoshikawa et al., 2013). In this regard, it is important to ensure that activities used in early childhood education are as enjoyable and interactive as possible. When children participate actively in activities, learning becomes more enjoyable, and the hands-on, experiential learning will make it more permanent.

Pre-School Basic Mathematical Concepts

Concepts are used to understand and define the key principles or features of a field and the relationships between different pieces of information in that field (Booth, 2011). A concept is a fundamental unit of all learning. People learn new concepts from

infancy to old age and use old concepts in new situations in their daily lives. Individuals vary in terms of their ability to form concepts, depending on their age, intelligence, and experiences (Manocha & Narang, 2004). For example, the concept of a square for a three-year-old child may differ from that of a high school student.

Learning mathematics is largely related to the development of concepts and is closely connected to the concrete experiences children have (İnan & Erkuş, 2019). For instance, when a child plays with a parent and is asked to give the longest pencil by the parent pointing at it, the child creates an experience. This experience will be very effective in helping the child understand and define the concept of "longest." Similarly, knowing their sibling count, their parent's phone number, the numbers on elevator buttons, and the numbers in hopscotch, all help children develop their sense of numbers through concrete experiences (Ölekli-Sönmez, 2021). A child helping to set the table for the family can be observed using the concept of matching.

It is important to recognize that in preschool children's mathematics education, children's enjoyment of learning and how it makes learning permanent is crucial. Moreover, effective mathematics teaching should involve training that allows children to apply steps of exploration, trial, and discovery (Akman, 2002).

Drama Method of Teaching

Drama is not only a way of learning by doing and experiencing but also a process where individuals benefit from their existing experiences to prepare themselves for new situations and developments (Aytaş, 2013). Drama is an educational tool that requires a high level of creativity. Dramatic activities help individuals better understand themselves and others (Çetingöz & Günhan, 2011). Through dramatic activities, children can discover and develop their own abilities and characteristics.

Some of the most important benefits of using drama in education include: facilitating the healthy expression of emotions, developing children's creative imagination, providing opportunities for independent thinking and self-expression, and increasing social awareness and collaboration (Tombak, 2014). The effective use of the drama method leads to the development of children's language and communication skills, encourages enthusiastic participation in lessons, and enables teachers to convey the intended content more effectively (Aytaş, 2013).

Since drama incorporates many features of play, it encourages children to engage in play as well. Play positively affects children's learning processes, and therefore, the drama method enables children to learn in an enjoyable and effective way (Yalım, 2009).

When used for concept teaching, the drama method fosters active participation, helps children concretize abstract concepts, and allows them to learn through hands-on experience. These qualities create a lasting and effective learning process while ensuring that children enjoy and learn through play (Sezer, 2008).

Music Method of Teaching

It is clear that music is an element that surrounds people in every moment of our lives, something that is always present and brings warmth to us (Kıvılcım & Mertoğlu, 2015). The introduction to music begins with lullabies in infancy and continues as music accompanies almost every part of life, including many memories. Since music is connected to memories, it enhances the permanence of those memories (Torun, 2022). The fact that when a person hears music, they recall a memory, demonstrates how music helps to make memories last. Just as it increases the permanence of memories, music can also be utilized to make learned information more lasting.

The connection between music and mathematics is believed to not only make math learning more enjoyable but also help ensure its lasting nature. Using musical activities during the teaching of many concepts can benefit the education process, as children willingly participate in musical activities, and the positive effects of music on children can enhance their learning experience (Dinçer, 2008).

In his thesis, Karşal (2004) examined the relationship between music and math success in preschool children. The study concluded that children who received music education performed better in mathematics compared to those who did not.

Given the importance of adequately knowing basic math concepts for primary school and later educational stages, Kıvılcım and Mertoğlu (2015) found that the music-based education program applied to early childhood children had a significant effect on their readiness for primary school in terms of math skills.

Direct Instruction Method

The direct instruction method is a teaching approach where the student is passive, and the teacher actively delivers the content, facilitating the acquisition of behavioral knowledge through explanation (Şahin, 2021). Compared to other teaching methods, the direct instruction method allows for the transfer of a large amount of information in a short time and is cost-effective, making it a convenient method that does not incur additional costs.

Due to its ease of use in mathematics lessons, the direct instruction method is frequently employed, but it does not align with the modern structured education approach. It is anticipated that this conventional method may cause difficulties for many students in solving non-routine problems at higher levels (Kablan et al., 2019). Since children are not actively involved, this method may often lead to boredom and distraction (Şahin, 2021). Nevertheless, the direct instruction method can be a useful tool for introducing the lesson, informing students about the objectives, capturing attention, and summarizing the topic at the end of the lesson (Dilci, 2011).

Research Related to the Topic

Ergül (2007), in his thesis titled "Turkish Adaptation of the Boehm Preschool Basic Concepts Test-3 for Children Aged 36-47 Months," examined the basic concept knowledge levels of 36-47 month-old children and conducted a Turkish adaptation of the Boehm Preschool Basic Concepts Test-3.

Çakmak (2012), in his study titled "Investigating the Effect of Concept Education Program in Teaching Basic Concepts to 60-71 Month-Old Children Attending Preschool Institutions," worked with 60-71 month-old children and explored the effectiveness of the concept education program used in teaching basic concepts to children.

Gazaioğlu (2019), in his study titled "Investigating the Basic Concept Knowledge and Problem-Solving Skills of Children Attending Kindergarten," researched the basic concept knowledge of preschool children and examined the impact of basic concept knowledge on their problem-solving skills.

Kırlar (2006), in his thesis titled "Comparative Study on the Effectiveness of Structured and Traditional Methods in Teaching Mathematical Concepts to Six-Year-Old Children in Preschool Education," compared structured education methods with traditional methods. The study found that children taught with traditional methods had lower mathematics achievement scores compared to those taught with structured methods. Kırlar (2006) recommended that mathematics education should be delivered using new-generation structured methods.

Ünal and Kaya (2024), in their study titled "Digital Games in Early Mathematics Education," investigated the benefits of using digital games in early childhood mathematics education. The research emphasized the importance of using interactive activities, where children take an active role, instead of the monotonous direct instruction method, which can make learning boring.

Karşal (2004), in his thesis titled "The Relationship Between Music Ability and Mathematical Ability in Preschool Children and the Effects of Music Education on Mathematics Performance," examined the relationship between music education and mathematics success in preschool children. The study found that children who received music education performed better in mathematics than those who did not. The research highlighted the importance of using music in early childhood mathematics education.

Kıvılcım and Mertoğlu (2015), in their study titled "The Impact of a Music Education Program on Preschool Children's Mathematical Skills and Readiness for Primary School," explored the effects of a music education program on mathematics education. They concluded that the music education program applied to early childhood children had a positive effect on their mathematical skills and readiness for primary school.

The Topic and Problem of the Study

The topic of this research focuses on the methods used for teaching basic mathematical concepts in preschool education. Identifying which of these methods are most effective and recommending their active use in schools is of great importance. In this context, the following sub-problems have been addressed:

- Does the drama-based teaching method have an impact on children's success in learning mathematical concepts?
- Does the direct instruction method influence children's success in learning mathematical concepts?
- Does the music-based teaching method affect children's success in learning mathematical concepts?
- Which of these methods is the most effective in teaching basic mathematical concepts?

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Purpose of the Study

The purpose of this study is to investigate whether music, drama, and direct instruction methods are effective in teaching basic mathematical concepts to children aged 48 to 60 months in preschool institutions, and to determine which of these methods is the most effective.

In the study, three groups of children are taught basic mathematical concepts using different methods: one group with music, one with drama, and the other with direct instruction. Based on this, the hypotheses of the study are as follows:

1. There is a significant difference between the pre-test and post-test scores of children who were taught mathematical concepts using the drama method.
2. There is a significant difference between the pre-test and post-test scores of children who were taught mathematical concepts using the direct instruction method.
3. There is a significant difference between the pre-test and post-test scores of children who were taught mathematical concepts using the music method.
4. There is a significant difference between the post-test scores of children taught mathematical concepts using the drama, direct instruction, and music methods.
5. When the pre-test scores from the Boehm Preschool Basic Concepts Test-3 are controlled, there is a significant difference in favor of the children taught with music in the post-test scores.
6. When the pre-test scores from the Boehm Preschool Basic Concepts Test-3 are controlled, there is a significant difference in favor of the children taught with the drama method in the post-test scores.

Importance and Rationale of the Study

Looking at the research in the literature related to basic mathematical concept knowledge:

Ergül (2007) conducted a study with children aged 36 to 47 months, and Çakmak (2012) worked with children aged 60 to 71 months, while this study focuses on children aged 48 to 60 months. Ergül (2007) investigated the level of concept knowledge in preschool children and found that most of the children exhibited normal development. Çakmak (2012) found that the concept education program they prepared had a positive impact on teaching, and Gazaioğlu (2019) discovered that children's level of basic concept knowledge positively influenced their problem-solving abilities. In this study, examining the effectiveness of the methods used is important because it plays a significant role in concept education for children.

When examining studies in the literature on methods used in early childhood education:

Kırlar (2006) compared traditional education with structured education in early childhood concept teaching and found that structured education was more effective. Ünal and Kaya (2024) argued that digital games are beneficial in early childhood education. Karşal (2004) found that teaching mathematics through music was beneficial, and Kıvılcım and Mertoğlu (2015) showed that a music education program positively impacted mathematical success and school readiness for primary school. This study investigates the effects of music, drama, and direct instruction methods in preschool education to complement and support these existing studies.

Given these findings, it is important to conduct more research on preschool children to achieve effective mathematics teaching. Additionally, there is no other study that examines the effectiveness of the music method, which is underutilized in preschool education, and the drama and direct instruction methods, which are widely used (Göllü, 2018; Yazlık & Öngören, 2018; Okur & Akçay, 2021). Understanding which method is more effective in teaching basic mathematical concepts in preschool education will guide teachers in planning their activities accordingly, making this research significant.

METHOD/MATERIALS

Research Design

Since the children participating in the study were in pre-assigned classes at schools affiliated with the Ministry of National Education (MEB), and random assignment to experimental groups was not possible, the study employed a non-equivalent groups pre-test post-test design, which is a suitable quasi-experimental research model among the quantitative research designs. The quasi-experimental design is frequently used in educational research and is considered a highly appropriate method when it is not possible to control all the variables in the study (Aydede & Matyar, 2009; McMillian & Schumacher, 2010). In this study, since all children attended predetermined classes at their own schools, it was not possible to randomly assign them to experimental and control groups. Therefore, the use of this design was deemed appropriate for the study.

Research Group

The study group for this research consisted of 44 children, including 20 boys and 24 girls, aged 48-60 months, attending public kindergartens under the Ministry of National Education (MEB) in Istanbul. A randomly selected school, which was easily accessible

to the researcher, was chosen, and three 4-year-old classes within the school were used for the study. Each class was treated as a group, and the study was conducted with three groups in total.

Data Collection Tools

For data collection in this study, the "Boehm Preschool Basic Concepts Test-3," adapted into Turkish by Ergül (2007), was chosen. The test is suitable for children aged between 3 years 0 months and 5 years 11 months. The test consists of 76 items. For children aged 3 years 0 months to 3 years 11 months, items 1-52 are applied. For children aged 4 years 0 months to 5 years 11 months, items 25-76 are applied. The information regarding the concepts in the items is provided in Table 1.

Table 1. Item Pairs and Concepts in the BOÖTKT-3

Articles	Concepts	Articles	Concepts
25-39	Nearest	38-52	Biggest
26-40	Finished	53-65	Before
27-41	Smallest	54-66	Most distant
28-42	Across	55-67	At the bottom
29-43	Different	56-68	Shortest
30-44	Longest	57-69	Last
31-45	In front of	58-70	Under
32-46	Both	59-71	Together
33-47	Around	60-72	A little but not much
34-48	Longest	61-73	In the middle
35-49	A lot	62-74	First
36-50	Same	63-75	Between
37-51	Most	64-76	Least

As shown in Table 1, there are two items for examining whether all the concepts are known or not. However, the children's responses to the test items provide a more reliable indication of whether they know the concepts.

The test consists of a manual with pictures of children. On the pages that contain pictures to evaluate all the basic concepts, the child is expected to point to the picture corresponding to the concept asked in the question. Before the picture-based items, which assess the concepts, all children are asked four practice questions to determine if they are capable of taking the test. The responses to these practice items are not included in the final score. To determine whether the children are ready for the test, they must answer all the questions in these four items correctly.

Data Analysis

For the test used in the study, a score of 1 was assigned for a correct answer and a score of 0 for an incorrect answer. The scores for all item pairs were summed up to calculate the total score for each concept. For each concept, there are two items, and the maximum score a child can receive for a concept is 2, while the minimum score is 0. The scores for each concept were summed up, and the total raw score obtained was considered the child's overall score on the test. Children could earn a maximum of 52 points on this test.

During the pre-test and post-test data collection, the entire test was administered to the children; however, only the scores from the four concepts that constituted the content of the training were considered. Since the skewness (0.702) and kurtosis (0.357) values of the data fall within the range of -1 to +1, the data were found to be normally distributed (Hair et al., 2013). The effectiveness of each method was analyzed using a dependent sample t-test. Furthermore, the variances were found to be homogeneously distributed ($p > .05$). Since these assumptions were met, the data were analyzed and compared using ANCOVA.

Implementation Process

Before the data collection process of the study began, the necessary discussions were held with the school, and the school was informed about the process. The required permissions and ethical approvals were obtained from the Ministry of National Education (MEB). The parents of the children were informed about the study, and consent was obtained.

The test was administered individually to each child in a distraction-free and appropriate environment. All children answered the test questions during a process that lasted approximately 15-20 minutes. During the test, no guidance was provided regarding the answers, and no facial expressions or verbal cues indicating whether the answers were correct or incorrect were used. The children's responses were coded as 1 for correct answers and 0 for incorrect answers.

To obtain pre-test and post-test data, the BPBCT-3 was administered to the children. Since the study was conducted with 4-year-old children, only the questions from items 25 to 76 were asked.

A pre-test was administered to the children, and then the descriptive analysis of the scores obtained from the test was conducted. Four concepts, for which the children received low scores, were selected. A total of 12 educational activities were planned to teach these selected concepts using music, drama, and direct instruction methods. The method to be used in each class was randomly determined through a lottery. Classroom teachers were informed in advance not to provide any instruction related to these concepts. Each class received 4 activities over a 4-week period, with 1 activity per week. Examples of the activities are provided in the appendices. After the activities, a 1-week waiting period was observed, and the post-test was conducted.

FINDINGS

In order to answer the research problem, the results of the analysis of the data obtained with the BPBCT-3 are presented in this section.

Children's Concept Knowledge

The percentages of children's knowledge of concepts are shown in Table 2.

Table 2. Findings regarding the percentages of children's knowledge of concepts

Concept Name	Knowledge Percentage (%)	Concept Name	Knowledge Percentage (%)
Nearest	85,24	Biggest	100,00
Finished	97,78	Before	61,83
Smallest	100,00	Most distant	73,17
Across	85,32	At the bottom	96,67
Different	89,77	Shortest	70,43
Longest	91,43	Last	46,86
In front of	72,34	Under	92,90
Both	71,75	Together	69,01
Around	32,98	A little but not much	57,82
Longest	94,44	In the middle	78,89
A lot	98,89	First	72,42
Same	98,89	Between	43,10
Most	97,78	Least	87,54

As seen in **Table 2**, the concepts with the highest knowledge percentages are *'largest'* and *'smallest'* (100%). These concepts are well-known by the children. After *'largest'* and *'smallest'*, the most well-known concepts are *'many'* and *'same'* (98.89%). The least known concept is *'around'* (32.98%). As can be seen in the table, other concepts with lower knowledge percentages include *'between'* (43.10%), *'at the end'* (46.86%), and *'a little but not much'* (57.82%).

Children's Developmental Levels

The interpretation of whether the children's development is normal can be made based on the raw scores they obtained from the test. The total scores obtained by the children and the performance range corresponding to these scores are shown in Table 3.

Table 3. Raw Scores of Children and the Performance Range Corresponding to Them

Performance Ranges	Raw Scores	N	%
1	33-52	41	93,18
2	26-32	3	6,82

When Table 3 is examined, it is observed that the majority of the children who took the test have a good understanding of the concepts. However, it is also noted that only three children in the study are lagging behind their peers.

Findings Related to the Drama Method

Table 4. Results of the Dependent Samples t-Test Analysis of the Pre- and Post-Test Scores of Children Trained with the Drama Method

Test	N	X	s	T	p
Pre-Test	15	4.40	2.20	-3.52	.001
Post-Test		5.60	1.96		

When Table 4 is examined, it is seen that in the dependent groups t-test analysis of the pre-test and post-test scores of children who received education using the drama method, the average score of the pre-test was 4.40, while the average score of the post-test was 5.60. The children's average score increased by 1.20. The results of the dependent samples t-test analysis show that there is a significant difference between the average pre-test and post-test scores, with the post-test scores showing a higher average ($p < .05$). In this case, it can be concluded that the children learned the concepts better after the education with the drama method compared to before the training.

Findings Related to the Direct Instruction Method

Table 5. Results of the Dependent Samples t-Test Analysis of the Pre- and Post-Test Scores of Children Trained with the Direct Instruction Method

Test	N	X	s	T	p
Pre-Test	14	2.93	1.94	-2.5	.04
Post-Test		3.86	2.11		

When Table 5 is examined, it is observed that in the dependent groups t-test analysis of the pre-test and post-test scores of children who received education using the direct instruction method, the average score of the pre-test was 2.93, while the average score of the post-test was 3.86. The children's average score increased by 0.93. The results of the dependent samples t-test analysis show that there is a significant difference between the average pre-test and post-test scores, with the post-test scores showing a higher average ($p < .05$). In this case, it can be concluded that the children learned the concepts better after the education with the direct instruction method compared to before the training.

Findings Related to the Music-Based Teaching Method

Table 6. Results of the Dependent Samples t-Test Analysis of the Pre- and Post-Test Scores of Children Trained with the Music-Based Instruction Method

Test	N	X	s	T	p
Pre-Test	15	3.33	1.76	-7.87	.001
Post-Test		5.53	1.46		

When Table 6 is examined, it is observed that in the dependent groups t-test analysis of the pre-test and post-test scores of children who received education using the music-based instruction method, the average score of the pre-test was 3.33, while the average score of the post-test was 5.53. The children's average score increased by 2.20. The results of the dependent samples t-test analysis show that there is a significant difference between the average pre-test and post-test scores, with the post-test scores showing a higher average ($p < .05$). In this case, it can be concluded that the children learned the concepts much better after the education with the music-based instruction method compared to before the training.

Findings Related to the Comparison of the Methods

The scores obtained by the children from the test have been analyzed, and the ANCOVA analysis findings are presented in Table 7.

Table 7. ANCOVA Analysis Findings

Source	Sum of squares	SD	Mean of squares	F	P	Effect size
Adjusted model	110.07	3	36.69	24.91	.01	.65
Intersection	58.95	1	58.95	40.03	.01	.50
Pre-test	82.14	1	82.14	55.78	.01	.58
Teaching methods	13.84	2	6.92	4.70	.01	.19
Error	58.91	40	1.47			
Total	279.00	44				
Adjusted total	168.98	43				

When Table 7 is examined, it is observed that there is a significant relationship between the children's mathematics concept knowledge levels before the education and their mathematics concept knowledge levels after the education ($p < .05$). When the pre-test scores of the methods used are controlled, it has been determined that they have a significant effect on the children's mathematics concept knowledge levels after the education ($F = 4.70$, $p < .05$, $r = .19$).

Regarding the research sub-question of which method is more effective, the ANCOVA analysis can be interpreted by controlling the pre-test scores and using the average post-test scores. These values are provided in Table 8.

Table 8. Post-Test Averages When Pre-Test Scores Are Controlled

Methods	$\bar{X}$	SE
Drama	5.00	.32
Music	5.70	.31
Direct Instruction	4.32	.33

* Pre-test means = 3,57

When the averages are examined, it is observed that the group trained with the music-based instruction method has the highest average, suggesting that this method is the most effective. On the other hand, due to the lowest average in the group trained with the direct instruction method, it can be concluded that this method is the least effective.

DISCUSSION AND CONCLUSION

In the study, subheadings such as the percentage of 48-60 month old children who continue their education in preschool education institutions knowing basic mathematical concepts, their developmental levels and which of the methods used in teaching basic mathematical concepts has a greater effect than others were examined.

When children's basic mathematical concept knowledge is examined, it is seen that they know most of the concepts. It has been determined that the least known concept is the concept of perimeter, and it has been observed that this concept is not emphasized in the preschool curriculum. It can be said that this situation is quite effective in the fact that the concept is so little known. Although most children encounter this concept in their daily lives, they do not know the visual meaning of the concept. It is thought that not teaching this concept in the preschool period will cause children to have difficulty in finding the perimeter lengths and areas of polygons in the later stages, and to confuse the perimeter and area formulas.

It has been observed that most of the children's developmental levels are progressing as they should, and accordingly, it can be said that they actively participate in the training and can focus better.

When we look at the applied education, it is seen that children can learn concepts to a certain extent as a result of all methods. As a result of the analysis, it is seen that the method that shows the least effect is the direct narration method. Since the direct narration method makes learning boring not only in preschool education level but also in most education levels, it should be preferred less. Since children need to participate more actively in education in order for their concentration period to be extended, the direct narration method reduces the concentration period due to children not being able to actively participate. The efficiency that children get from education decreases with the decrease in the concentration period.

Ünal and Kaya (2024) also defended the importance of using more entertaining and interactive activities in which children play an active role instead of using boring plain narrative methods in the education of preschool children in their study investigating digital games in early childhood education. Since children have a task to do in interactive activities, they follow the education more carefully and try to do their duty. For this reason, care should be taken not to let children remain passive in education in order to increase focus.

Kırlar (2006) made a comparison of the structured and traditional preschool methods in his thesis. It was determined that the scores of children who received education with the traditional method were lower than the scores of children who received education with the structured method. Considering this situation, it was recommended that preschool mathematics education be given together with methods such as music, games and drama.

As a result of the analysis, it was seen that the method of narration with drama was quite effective in teaching basic mathematical concepts in preschool. In order for the method to be more useful, children may need to be informed about what drama is and how it is done. Drama is a teaching method that is both difficult to apply for both the teacher and the child, but also enjoyable. Although this method is effective, it is difficult to apply for every concept.

Since many sensory organs are actively used in drama studies, it can be said that it positively affects other developmental areas, including cognitive development (Başdemir, 2024). It is very important for a method to appeal to more than one area. In this way, while the teacher's aim in doing the activity is to teach a concept, it also benefits the child in several different developmental areas such as social and cognitive.

In Kanak and Pekdoğan (2018) stated in their research that preschool teachers generally prefer the direct instruction method because they see themselves as inadequate. Similarly, this research draws attention to the fact that preschool teachers should use methods other than direct instruction in their lessons. Gresham and Burleigh (2018) also point out that preschool teachers should use structured education, but that they should receive adequate training in this regard. It is mentioned that as teachers receive training in the use of various methods, they will be able to apply those methods to children more easily and correctly, and thus prefer them more.

It is very important for preschool teachers to have materials that will support children's academic skills and to organize activities in a way that children will actively participate. It will be beneficial if the environment is suitable for the activity, as it will increase the efficiency of the activity and the teacher's desire to do the activity will increase when the material is easily accessible. This situation was also stated by Uyanık and Kandır (2010) in their study.

In their study, Bilgin (2024) stated that preschool teachers think that children learn more easily when they have fun while teaching mathematics to preschool children. It was also mentioned that children who have difficulty learning are taught concretely with materials or games they like. It is also very important for teachers to realize that some children learn mathematics with different methods and to determine suitable methods for these children and organize education for them. The fact that this study supports the results and the importance of having a variety of activities is seen in the feedback collected from the teachers in the study results.

It has been observed that the method of narration with music is the most effective teaching method in teaching basic mathematical concepts to children aged 48-60 months. These activities take into account the learning differences of children in terms of appealing to more than one sense organ, and they are very entertaining and actively participated by children. Since there is no need for a method education like the method of narration with drama, almost every child can be actively involved in the education. It is also a very easy method for teachers to use in terms of designing activities for almost every concept.

Another study that will confirm the results of this study is Karşal's (2004) thesis examining the relationship between music and mathematics achievement in the preschool period. As a result of the study, it was seen that children who received music education were more successful in mathematics than children who did not, and the importance of using music was emphasized. Another study conducted by Kıvılcım and Mertoğlu (2015) examined the effect of the music education program applied to early childhood children on their readiness for primary school in terms of mathematics skills, and similar results were reached, again emphasizing that the inclusion of music in mathematics education would yield positive results. Similarly, Whitehead (2001) stated in his study that the use of music in teaching mathematics positively affected academic achievement.

In the study conducted by Günaydın et al. (2023), although they worked with different samples and four methods, similar results were obtained. In the study, it was seen that the narration method with music and drama was quite effective in teaching basic mathematics concepts in pre-school. It was mentioned that the direct narration method should be preferred less because it causes distraction in children and has little benefit in effective teaching, and teachers should prepare their activities using music and drama methods, which are very beneficial in effective teaching of basic mathematics concepts in pre-school.

RECOMMENDATIONS

Suggestions for Researchers:

In this study, drama, music, and direct instruction methods were examined, and researchers may be encouraged to compare additional methods. While looking at research on the most and least commonly used teaching methods in preschool mathematics education, there was a lack of sufficient information. Therefore, conducting further studies in this area is also recommended.

Suggestions for Preschool Teachers:

Preschool teachers are advised to avoid using the direct instruction method when planning their activities and to instead focus on methods like drama and music that encourage active participation from children. As seen in the results of this study, music-based teaching is very effective. Therefore, even when using a different method, it is recommended that teachers incorporate the concept being taught into a song or musical activity to enhance the lesson.

Declaration of Conflicting Interests

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

Funding

The authors received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Examples of author contribution statements

N.G. and B.K.D. conceived of the presented idea. N.G. developed the theory and performed the computations. B.K.D verified the analytical methods. B.K.D. encouraged N.G. to investigate [a specific aspect] and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

Researchers' contribution rate

The authors contributed equally to all processes of the article. The authors have read and approved the final version of the article.

Ethics Committee Approval Information

The ethics committee document of this study was approved by the ethics committee decision of Bayburt University Rectorate dated 23.05.2022 and numbered 70389.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 276-285
doi: 10.24106/kefdergi.1683443

| Research Article / Araştırma Makalesi |

Investigating the contextual realism levels of the mathematics contents in curriculum resources in Türkiye

Türkiye müfredat kaynaklarındaki matematik içeriklerinin bağlamsal gerçeklik seviyelerinin araştırılması

Semahat Incikabi[1]

Keywords

1.Realistic mathematics education
2.Mathematics textbooks
3. Centralized exams
4. Curriculum resources
5. Contextual reality

Anahtar Kelimeler

1.Gerçekçi matematik eğitimi
2.Matematik ders kitapları
3.Merkezi Sınavlar
4.Müfredat kaynakları
5.Bağlamsal gerçeklik

Received/Başvuru Tarihi
01.11.2024

Accepted / Kabul Tarihi
20.04.2025

Abstract

Purpose: The current study aims to investigate the realistic level of curriculum resources (textbooks and national examinations) in Turkey.

Design/Methodology/Approach: Being qualitative in nature, the current study utilized the document analysis method to examine contextual reality aspects of curriculum resources. The source for this study comprises the centralized assessments for secondary education institutions (CASEI) implemented since 2018 and a middle school mathematics textbook. 749 content items (609 from textbooks and 140 from examinations) were investigated in order to determine the realistic structure of the curriculum resources. In order to reveal the contextual reality level of mathematical problems, I have utilized a rubric including event, question, language use, existence of information/data, realism of information/data, specificity of information/data, and affective purpose aspects.

Findings: The results indicated that a significant portion (more than 90%) of the questions in textbooks and in exams remain at the poor-fit level. In contrast, the number of questions reaching the good-fit level in terms of contextual realism is quite limited, with only 3 items in textbooks and 4 items in CASEI. The results of the current study also reveal that some items from both sources fall into the stereotyped score level in terms of total score but are categorized as poor-fit contextual reality due to inadequacies in one or more core components of contextual realism. When evaluating the competency statuses of the contextual reality components in the CASEI and textbook questions, it is observed that the majority of questions are largely inadequate in components other than language use. In particular, the rate of inadequate problems is notably higher in the question, specificity of information, and affective purpose components. On the other hand, in addition to the language use component, it can be said that the number of questions with acceptable competency in the realism of information and event components, although at low rates, is higher than the other components. Furthermore, compared to textbooks, the number of questions in CASEI with partial sufficient and sufficient competency for each component is higher.

Highlights: The results of the study indicated curriculum resources' in adequacy regarding contextual reality framework. The results discussed in detail, and suggestions were provided accordingly. Further research is required to gain a comprehensive understanding of the reflections of the inadequacies identified in this study on teachers and students. Additionally, intervention studies to enhance the contextual relevance levels of the problems will contribute to the existing literature on this topic. It is also recommended that research be conducted to examine the reflections of the competencies related to contextual realism in different curriculum resources.

Öz

Çalışmanın amacı: Bu çalışma, Türkiye'deki müfredat kaynaklarının (ders kitapları ve ulusal sınavlar) gerçeklik düzeyini araştırmayı amaçlamaktadır.

Materyal ve Yöntem: Nitel bir doğaya sahip olan mevcut araştırma, müfredat kaynaklarının bağlamsal gerçeklik durumlarını incelemek için doküman analizi yöntemini kullanmıştır. Bu çalışmanın kaynağını, 2018 yılından itibaren uygulanan ortaöğretim kurumları için merkezi sınavlar (CASEI) ve bir ortaokul matematik ders kitabı oluşturmaktadır. Müfredat kaynaklarının gerçeklik yapısını belirlemek amacıyla 749 içerik (609 ders kitabından ve 140 sınavdan) incelenmiştir. Matematiksel problemlerin bağlamsal gerçeklik düzeyini ortaya koymak amacıyla, olay, soru, dil kullanımı, bilgi/veri varlığı, bilgi/veri gerçekçiliği, bilgi/veri özgüllüğü ve duyuşsal amaç unsurlarını içeren bir rubrik kullanılmıştır.

Bulgular: Sonuçlar, ders kitaplarındaki ve sınavlardaki soruların önemli bir bölümünün (%90'dan fazla) düşük uyum seviyesinde kaldığını göstermektedir. Buna karşılık, bağlamsal gerçekçilik açısından iyi uyum seviyesine ulaşan soru sayısı oldukça sınırlıdır; ders kitaplarında yalnızca 3 ve CASEI'de 4 soru bulunmaktadır. Mevcut çalışmanın sonuçları ayrıca her iki kaynaktan bazı maddelerin toplam puan açısından kalıplaşmış puan seviyesine ulaştığını, ancak bağlamsal gerçekliğin bir veya daha fazla temel bileşenindeki yetersizlikler nedeniyle düşük uyum seviyesinde kategorize edildiğini ortaya koymaktadır. CASEI ve ders kitabı sorularındaki bağlamsal gerçeklik bileşenlerinin yeterlilik durumları değerlendirildiğinde, dil kullanımı dışındaki bileşenlerde soruların büyük ölçüde yetersiz olduğu gözlemlenmiştir. Özellikle soru, bilgi özgüllüğü ve duyuşsal amaç bileşenlerinde yetersiz problem oranı dikkat çekici şekilde daha yüksektir. Öte yandan, dil kullanımı bileşenine ek olarak, düşük oranlarda da olsa bilgi gerçekçiliği ve olay bileşenlerinde kabul edilebilir yeterlilik düzeyine sahip soru sayısının diğer bileşenlere göre daha yüksek olduğu söylenebilir. Ayrıca, ders kitaplarına kıyasla CASEI'de her bileşen için kısmen yeterli ve yeterli yeterliliğe sahip soru sayısı daha fazladır.

Önemli Vurgular: Çalışmanın sonuçları, müfredat kaynaklarının bağlamsal gerçeklik çerçevesi açısından yetersiz olduğunu göstermiştir. Sonuçlar detaylı bir şekilde tartışılmış ve ilgili önerilerde bulunulmuştur. Bu çalışmada tespit edilen yetersizliklerin öğretmen ve öğrenciler üzerindeki yansımalarının kapsamlı bir şekilde anlaşılabilmesi için daha fazla araştırmaya ihtiyaç duyulmaktadır. Ayrıca, problemlerin bağlamsal uygunluk düzeylerini artırmaya yönelik müdahale çalışmaları bu konudaki mevcut alan yazınına katkı sağlayacaktır. Bağlamsal gerçekçilikle ilgili yeterliklerin farklı müfredat kaynaklarındaki yansımalarını inceleyen araştırmaların yapılması önerilmektedir.

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Citation/Alıntı: İncikabı, S. (2025). Investigating the contextual realism levels of the mathematics contents in curriculum resources in Türkiye, *Kastamonu Education Journal, 33*(2), 276-285. doi: 10.24106/kefdergi.1683443

INTRODUCTION

Among the goals of mathematics education is to teach students to identify and understand the connection between mathematics and the real world (Niss, Blum & Galbraith, 2007). Realistic problem-solving is now recognized as central to the educational standards of many countries around the world, and they are seen as crucial elements in the current understanding of mathematical competence (Hankeln, 2020). Curriculum documents in many countries clearly support the benefits of relating school mathematics to real life (e.g. Brenner & Moschkovich 2002; Verschaffel, Greer & De Corte, 2000). As one of the process standards and guiding principles for curriculum and assessment, the National Council of Mathematics Teachers (2000, 2009) has consistently emphasized the importance of linking subjects with students' daily lives. Moreover, the reformed mathematics teaching program of Turkey also highlights the use of realistic problems in the mathematics teaching process by requiring applying math content to real-life situations and explaining their connection to reality (MNE, 2024).

Commercial curriculum materials have a significant impact on school practices, which is clearly highlighted by researchers such as Jitendra, Deatline-Bunchman, and Sczesniak (2005). It is essential to note that textbooks are thoughtfully developed in alignment with the national objectives that are outlined in the intended curriculum. These resources play a critical role in shaping the nature of classroom instruction that is based on the implemented curriculum. As a result, textbooks serve as a vital linkage between the curriculum and educators, a relationship pointed out by Viholainen et al. (2015). Furthermore, they symbolize the potentially implemented curriculum, as discussed in works by scholars like Fukkink (2010), Lepik (2015), and Pepin & Haggarty (2001). In investigating research related to the enacted curriculum, it becomes evident that textbooks exert a considerable influence on teaching methodologies. This influence stems from the fact that teachers tend to closely adhere to the topics, problems, tasks, and instructional strategies that are presented in textbooks while planning their lessons (Ulusoy & Incikabi, 2023). This adherence continues through various classroom activities, the assignment of homework, and the introduction of new subjects to students (Gracin, 2011; Gracin & Matić, 2016; Haggarty & Pepin, 2002; Pepin & Haggarty, 2001). In this intricate context, it is crucial to conduct a thorough examination of how the expectations outlined in mathematics curricula regarding realistic mathematics education are reflected within the contents of textbooks. This investigation could reveal important insights into the alignment between curriculum expectations and teacher practices in mathematics education.

Many countries employ national exit examinations to certify and signal the achievements of secondary school students to universities and employers. Bishop (1998) defined curriculum-based exit examinations as producing “signals of student accomplishment that have real consequences for the student, define achievement relative to an external standard, not relative to the other students in the classroom or the school …, are organized by discipline and keyed to the content of specific course sequences …, signal multiple levels of achievement in the subject …, cover almost all secondary school students …, and assess a major portion of what students studying a subject are expected to know or able to do (Bishop 1998, pp. 171, 172). ” Standardized tests may also influence a teacher’s choice of content for classroom instruction. In fact, an earlier study of teachers’ responses to hypothetical schools indicated that, when a school district reports test results by grade level in the local newspaper, standardized tests may function as one of the strongest sources of curriculum influence (Floden et al. 1981). In a study of the high school curriculum in Korea, Kim (2005) claimed that the college entrance examinations have significantly influenced high school classroom teaching-learning activities, yielding a curriculum different from the formal curriculum. Besides the textbooks’ adaptation of real-life situations, analyzing real-life skills addressed in standardized exams, which have the potential to guide classroom practices, is important in terms of meeting curriculum expectations regarding the application of mathematics to real-life situations. Hence, the current study aims to investigate the contextual reality level of curriculum resources (textbooks and national examinations) in Turkey. For this purpose, I addressed the following research question in this study: When evaluated within the framework of contextual problems, what are the levels of contextual realism in the problems presented in textbooks and in the high school entrance examinations?

Contextual problems in mathematics education

The extensive literature on the various contextual properties of mathematics problems highlights the crucial significance of incorporating real-world applications and cognitive processes in the context of problem-solving. This emphasizes how these elements profoundly influence student engagement and understanding throughout the learning process. Research consistently indicates that integrating contextual elements into mathematics instruction not only significantly aids in the development of essential problem-solving skills but also fosters a much deeper and more comprehensive understanding of various mathematical concepts (e.g., Bonotto, 2007; Marco & Palatnik, 2023). Numerous studies have compellingly shown that when students encounter mathematics problems that are framed within relatable real-life scenarios, they are far more likely to engage meaningfully with the material and apply their accumulated knowledge effectively in various situations (Reinke & Casto, 2020; Verschaffel et al., 2020). Consequently, real-world problems have notably emerged as a pivotal and critical element in mathematics curricula worldwide, as evidenced by numerous educational frameworks (e.g., MNE, 2018; NCTM, 2000). The mathematics education literature robustly reflects this growing focus, featuring a variety of terms used to describe such problems, including but not limited to, realistic problems, modeling problems, word problems, contextualized problems, context problems, real-world problems, and authentic problems, as noted by Jurdak in two of his significant works (2006, 2016) and Verschaffel and colleagues (2020). In the context of this research, the term "contextually realistic mathematics problems" is adopted intentionally to underscore the

importance of engaging with substantial mathematical ideas and the inclusion of meaningful, relevant real-life contexts that facilitate learning.

The essential components of a realistic problem are a topic of significant and ongoing discussion among task developers in the field of education and problem-solving methodologies (Palm, 2006). In this regard, Palm's comprehensive framework (2008, 2009) stands out for its thoroughness and detailed analysis of what constitutes a realistic problem. According to Palm (2008), five fundamental elements serve to characterize a realistic problem: event, question, purpose, language, and information/data. The term "event" is understood to refer to scenarios that either occur in reality or have a plausible chance of occurring in real-life situations. Within this context, the "question" emphasizes the essential relationship between tasks assigned in educational settings and their analogous situations that may exist outside the classroom. Moreover, the "purpose" denotes that the objective of the task should be clear, straightforward, and uncomplicated for the learner to grasp. Additionally, research on realistic problems has underscored the importance of affective elements in problem-solving and problem-posing, alongside the cognitive factors that learners engage with (Jonassen, 2000; Jonassen & Tessmer, 1996). Consequently, the affective aspect related to the overall purpose has been integrated into the criteria for real-world problems of this nature. The dimension of language encompasses the terminology, sentence structure, and overall length of text utilized to express the task in a manner that is comprehensible and beneficial to students. Lastly, the information/data category is further categorized into three critical aspects: the availability of information/data, the realism of that information/data, and the specificity of the information/data presented. The availability aspect ensures that the information provided is appropriately aligned with the knowledge and context relevant to the modeled situation being addressed. The realism aspect emphasizes that figures and values used are credible, either matching or closely resembling those found in the theoretical scenario proposed. Finally, the specificity aspect signifies that the scenario described in the task represents a distinct and clearly defined situation, complete with identifiable entities, objects, and locations.

METHODOLOGY

Being qualitative in nature, the current study utilized the document analysis method to examine realistic aspects of curriculum resources. Document analysis includes recording the existing records and documents related to the subject to be investigated and then coding these documents according to a certain norm or system (Cohen, Manion, & Morrison, 1994).

Data Collection Sources

In Turkey, centralized secondary school transition examinations have been conducted since 1998 to assess primary school student's achievements and improve the quality of education, undergoing five changes in terms of content and implementation processes. Particularly, the fact that Turkish students lag behind in international competition (as seen in the results of assessments like TIMSS and PISA) has led to a reevaluation of the education, teaching, and assessment systems (Gündoğdu, Kızıltaş, & Çimen 2010). In this context, the transition system to high schools was reorganized starting in 2018. In this system, centralized assessments were conducted only at the 8th grade for secondary education institutions that will admit students through examination, with a shift in exam question contexts (MEB, 2018b), moving to a format known as 'new generation' questions, which emphasize mathematical literacy and real-life skills (Atasoy, 2019; Dolapçıoğlu, 2020; 25. Incikabi, Sadak, & Incikabi, 2023; Korkmaz, Tutak, & İlhan, 2020; Ünal, 2019). This exam, administered centrally by the Ministry of National Education across Turkey, allows students in the 8th grade of public and private high schools, Imam Hatip high schools, and temporary education centers to gain admission to Science High Schools, Social Science High Schools, Special Program and Project Implementing Educational Institutions, and the Anatolian Technical Programs of Vocational and Technical Anatolian High Schools (MNE, 2018). In this context, the examination source for this study comprises the centralized assessments for secondary education institutions (CASEI) implemented since 2018.

In this study, the textbooks were selected based on a purposive sampling strategy. This study aims to examine the levels of realism in curriculum resources within the context of textbooks and national examinations. Since 2018, Turkey has revised the transition system to secondary education, introducing a national examination based on mathematical literacy targeting 8th-grade topics and administered to 8th-grade students. Therefore, it was deemed appropriate to analyze 8th-grade textbooks to ensure alignment between exam and textbook content. In this regard, a textbook approved for use in public schools by the Ministry of National Education (MNE) and currently in use has been included in the scope of this review.". Turkey utilizes standardized textbooks in their classrooms, and textbooks are compulsory in primary and secondary education. The adoption of a textbook for instruction depends on the approval of the Ministry of National Education. Turkish textbooks are evaluated on the basis of four basic dimensions: (1) conformity to the instructions of the Ministry of National Education, (2) scientific competence, (3) the level of achievement of instructional objectives, and (4) the quality of visual and content design. .

Contents of the Curriculum Sources

I used problems and examples as the content of the analysis. Textbooks covered these contents under the headings of "problems," "exercises," and "examples". In this regard, Table 1 shows the distribution (f) of the contents to be analyzed in textbooks and centralized assessments for secondary education institutions (CASEI). According to Table 1, a total of 749 content items (609 from textbooks and 140 from examinations) were investigated in order to determine the realistic structure of the curriculum resources.

Table 1. Content distribution across the curriculum sources (f)

Source of the Content	Problem	Exercises	Examples
Textbook	39	274	296
CASEI	140		

Coding procedures

The system developed by Vicente and Manchado (2016) was utilized to ascertain the contextual reality level of the mathematics problems. The system was augmented with components of affective purpose, drawing from the seminal study of Tran et al. (2020). The final version of the analytical system, designed to determine the contextual reality level of mathematical problems, considers the following aspects: The event, the question, the language use, the existence of information/data, the realism of information/data, the specificity of information/data, and the affective purpose (see Table 2).

Table 1. A framework for analyzing of the level of contextual reality of mathematics problems

Core components	Insufficient	Partially sufficient	Sufficient
Event	Imaginary or fictitious	Possible but unlikely outside of school	Probable that the student will have the opportunity to engage outside of the school environment.
Question	Could not be asked in the real life setting.	Possible, but of limited interest to students.	Reasonable; its answer has practical value in real life
Language use	Complex terminology and unconventional sentence structure impede students' engagement with the problem.	The issue may be challenging terminology and/or inappropriate sentences. However, this did not impede effective problem-solving.	The issue is not complex terminology or unconventional grammar, as long as these are not used in real-world situations.
Existence of information/data	The information is not consistent with reality.	The information may exist in reality but is seldom found	The information is consistent with data that can be verified in the physical world.
Realism of information/data	The problem situation lacked the inclusion of realistic values and numbers.	Some data is consistent with the values and variables observed in the scenario, exhibiting a high degree of correlation.	The numbers and values given are realistic in the sense of identical or very close to the corresponding numbers and values in the problem situation.
Specificity of information/data	Neither the subjects nor the objects involved are specified.	The situation is not specific, but the objects, roles, or names of the people are	People with names, defined objects and specific places
Affective purpose	The problem does not contain any expressions of purpose; there is no social, cultural, moral or intellectual need to solve the problem.	There is a purpose statement in the problem, but there is no social, cultural, moral, or intellectual need for solving the problem.	The purpose of the problem is clearly stated, and the context provides a social, cultural, moral, or intellectual need for solving the problem.

To assess the contextual realism of the problems analyzed, a three-level scoring system was developed. Each problem was evaluated across seven aspects, with scores of 1, 0.5, or 0 assigned to each. A score of 1 indicated that the aspect was presented in a way closely aligned with students' real-life experiences. A score of 0.5 was given when the aspect, while theoretically possible, was unlikely to occur in students' everyday lives. A score of 0 was used when the aspect was deemed implausible or disconnected from students' typical experiences. The sum of these scores determined the overall realism score for each problem. Problems were then categorized into three levels based on the total score, as defined in Table 3.

Good-Fit Problems were those scoring between 6 and 7 points. These problems accurately reflected everyday contexts familiar to students and demonstrated clear purpose, accessible language, realistic data, and affective relevance. For example, a problem involving the preparation of a dessert for a dinner gathering, which required careful time planning based on real-life recipe instructions, received full marks across all evaluated aspects. Stereotyped Problems, with total scores ranging from 4 to 5.5, included contexts that were technically feasible but less commonly experienced by students or presented with vague or generalized information. These problems often included flexible or nonspecific details that could apply to a broad range of contexts. Although some linguistic or structural issues were present, these did not significantly hinder problem comprehension or resolution. Poor-Fit Problems received scores of 3.5 or lower and were characterized by missing or underdeveloped contextual elements. These problems often presented unrealistic or unclear scenarios and prioritized procedural computation over meaningful problem-solving. An example includes a travel-based problem that asks students to compute arrival time without providing a practical or affective rationale for doing so.

To ensure the validity and reliability of the scoring, two independent experts with doctoral degrees in mathematics education and research backgrounds in contextual problems were recruited. Each expert independently coded the problems using the

defined criteria. Inter-rater reliability was calculated using Miles and Huberman's (1984) formula, yielding an initial agreement rate of 81.5%. Disagreements were discussed and resolved through consensus, resulting in a finalized and agreed-upon dataset for analysis.

Table 3. Levels of contextual reality according to the score of each problem on each aspect

Type	Event	Question	Language use	Existence of Info.	Realism of Info.	Specificity of Info.	Affective Purpose	Problem Score
Good-fit	1	1	1	1	1/0.5	1	1/0.5	6-7
	1	1	1	1	1	1/0.5	1/0.5	
Stereotyped	1	1	1/0.5	1	0.5	0.5	0.5	5/5.5
	1	0.5	1/0.5	0.5	0.5	0.5	0.5	4/4.5
	0.5	1	1/0.5	0.5	0.5	0.5	0.5	
Poor-fit	0.5	0.5	0.5	0.5	0.5	0.5	0.5	3.5
	1/0.5	1/0.5	0.5	0.5	0.5	0		
	1/0.5	0.5	1	0.5	0			
	1/0.5	1/0.5	1	0				
	1/0.5	0.5	0					
	0.5	0						
	0							

Note: Following Palm and Burman (2004), when a main aspect scored 0, the analysis was halted, and a total score of 0 was assigned.

Ethical Issues

This study does not involve any living subjects, so there is no situation involving an ethical violation. Care has been taken to ensure that the selected samples for analysis do not contain any elements that could disadvantage any individual, gender, group, or race.

FINDINGS

Figure 1 illustrates the levels of contextual realism of the questions included in the examined resources. Upon reviewing the figure, it is evident that a significant portion of the questions remains at the poor-fit level, with 98% (f=595) in textbooks and 93% (f=130) in exams. The number of questions reaching the good-fit level in terms of contextual realism is quite limited, with only 3 items in textbooks and 4 items in CASEI.

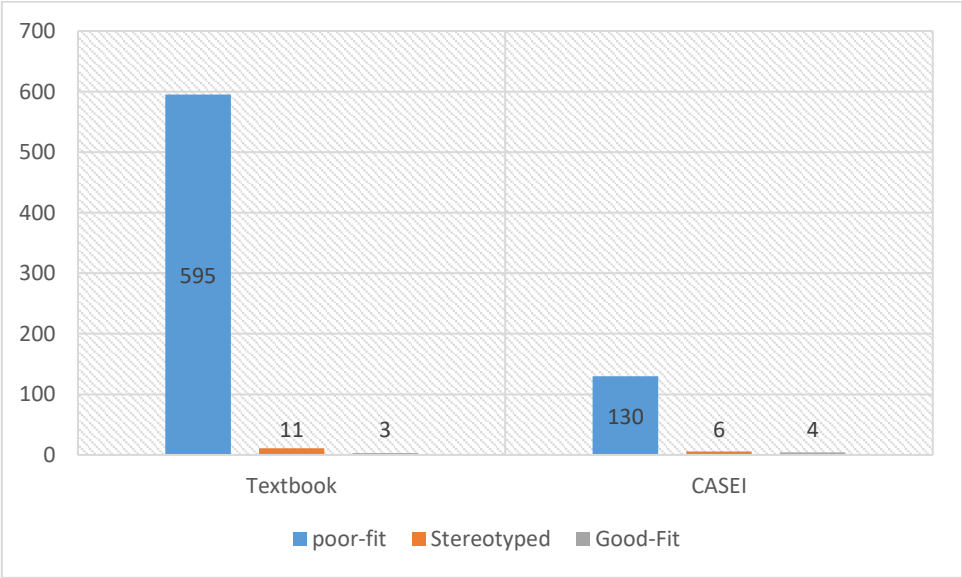

Figure 1. Contextual reality levels of the curriculum resources

Table 4 presents the total realism score distributions of problems included in curriculum resources. A general review shows that a significant portion of the problems (409 out of 609 in textbooks and 54 out of 140 in exam questions) have a total score of 1. Only 36 questions in textbooks (about 5%) and 29 questions in LGS exams (20%) surpassed the threshold score of 3.5, which is one of the criteria to qualify above the poor-fit level. Additionally, the table displays the total scores of problems within the poor-fit category. Accordingly, 22 textbook items and 19 exam items (colored in grey) fall into the stereotyped score level in terms of

total score but are categorized as poor-fit contextual reality due to inadequacies in one or more core components of contextual realism (receiving a score of 0).

Table 2. Contextual reality scores of curriculum resources (%)

	Contextual Reality Total Scores												
	1	1,5	2	2,5	3	3,5	4	4,5	5	5,5	6	6.5	7
Textbook	409	41	27	32	34	30	13	13	3	4	3		
Poor-fit	409	41	27	32	34	30	12	7	2	1			
CASEI	54	13	11	14	15	4	9	8	4	4	2		2
Poor-fit	54	13	11	14	15	4	8	5	3	3			
	Poor-fit score zone						Stereotyped score zone				Good-fit score zone		

Table 5 presents the distribution of questions found in the textbook and CASEI exams according to the components of contextual reality. The last column shows the percentages of questions that provide acceptable competency (partial sufficient or sufficient) based on the framework employed during the analysis process. According to the table, the language use component is addressed with adequate competency in both the textbooks and CASEI in relation to contextual reality. When evaluating the competency statuses of the textbooks across other components, it is noteworthy that the majority of questions (ranging from 70% to 90%) are inadequate, particularly in the components of question, specificity of information, and affective purpose, where the rate of inadequate problems is notably higher. On the other hand, in addition to the language use component, it can be said that the number of questions with acceptable competency in the realism of information and event components, although at low rates, is higher compared to the other components. When evaluating the competency statuses of the contextual reality components in the CASEI questions, it is observed that the majority of questions are largely inadequate in components other than language use. In particular, the rate of inadequate problems is notably higher in the question, specificity of information, and affective purpose components. Furthermore, compared to textbooks, the number of questions in CASEI with partial sufficient and sufficient competency for each component is higher. Additionally, it can be stated that there is a greater presence of questions with acceptable competency in the realism of information and event components.

Table 5. Distribution of competencies for the contextual realistic core components (%)

		Competency Level			
Source	Core Component	Insufficient	Partially Sufficient	Sufficient	(PS+S)
Textbook					
	Language Use	0.0	0.3	99.7	100.0
	Event	80.3	15.4	4.3	19.7
	Question	89.3	9.9	0.8	10.7
	Existence of Information	83.1	14.3	2.6	16.9
	Realism of Information	73.7	19.0	7.2	26.2
	Specificity of Information	87.5	6.4	6.1	12.5
	Affective Purpose	86.9	12.2	1.0	13.2
CASEI					0
	Language Use	0.0	0.7	99.3	100
	Event	52.1	34.3	13.6	47.9
	Question	72.9	16.4	10.7	27.1
	Existence of Information	64.3	22.1	13.6	35.7
	Realism of Information	55.7	30.7	13.6	44.3
	Specificity of Information	76.4	15.0	8.6	23.6
	Affective Purpose	71.4	24.3	4.3	28.6

DISCUSSION

The current study aimed to investigate the contextual reality level of the questions placed in the mathematics textbooks and CASEI centralized exams in Turkey. The results indicated that a significant portion (more than 90%) of the questions in textbooks and in exams remain at the poor-fit level. In contrast, the number of questions reaching the good-fit level in terms of contextual realism is quite limited, with only 3 items in textbooks and 4 items in CASEI. Bridging school mathematics and real-life situations has been one of the goals of mathematics education reforms, and in several studies, the mathematics education community

emphasized the potential benefits of integrating mathematics into real-life contexts on students' understanding of and motivation toward mathematics (Chapman, 2006; Gainsburg, 2008; Lee, 2012; Savard & Polotskaia, 2017). In this context, aligning the content of textbooks and standardized exams with real-world applications is critical, as these resources serve as direct reflections of educational philosophies within the classroom. When textbooks and exams lack relevant real-life connections, there is an increased risk that these skills may be neglected during classroom applications (Darling-Hammond, Ancess, & Falk, 1995; Kim, 2005; Rasmussen, 1997). Studies show that students in a such classroom setting persistently approach word problems with a calculational orientation (Thompson, Philipp, Thompson, & Boyd, 1994) and typically do not take into account realistic considerations about the problem situation (Cooper & Harries, 2003; Dewolf, Van Dooren, Hermens, & Verschaffel, 2015). This behavior leads to underachievement; the students do not make sense of the problem situation, and hence cannot show their full potential in solving problems from daily life (İncikabı, Ayanoğlu, & Uysal, 2020). There are indications from several studies that this effect might be counteracted or avoided by making the problem situations or the representation of the problem situations more authentic for the students (Palm, 2002, 2006, 2008, 2009; Verschaffel, Greer, Van Dooren, & Mukhopadhyay, 2009). Additionally, the limited emphasis on contextual reality in curriculum resources may negatively impact student learning and motivation. (Marco & Palatnik, 2023; Reinke & Casto, 2020). Rich contextual tasks have the potential to support students' mathematical learning, problem-solving, and motivation to learn (Cordova & Lepper, 1996; Walkington, Sherman, & Petrosino, 2012). The real-life context might help students to make sense of the mathematical relations involved in the problem and, on the other hand, might encourage students to check whether the solutions mathematically and contextually make sense, understanding of and motivation toward mathematics (Savard & Polotskaia, 2017). Moreover, the lack of real-life connections in textbooks particularly affects teachers' expectations of these resources. Prior studies indicate that teachers and students pay little attention to contexts described in traditional textbook tasks, and do not consider them a source for meaningful connections to "real-world" mathematics (Gainsburg, 2008; Wernet, 2009).

The results of the current study also reveal that some items from both sources fall into the stereotyped score level in terms of total score but are categorized as poor-fit contextual reality due to inadequacies in one or more core components of contextual realism. This situation indicates that, with small touches to the weak components, the realism of the questions in the examined resources can be elevated to the desired good-fit level. In this regard, it is posited that activities and application studies designed to enhance the awareness of content developers and evaluators regarding the fundamental components of contextual reality would be advantageous. Such initiatives are likely to foster a more relevant and effective educational experience, thereby aligning assessment practices with real-world applications. When evaluating the competency statuses of the contextual reality components in the CASEI and textbook questions, it is observed that the majority of questions are largely inadequate in components other than language use. In particular, the rate of inadequate problems is notably higher in the question, specificity of information, and affective purpose components. On the other hand, in addition to the language use component, it can be said that the number of questions with acceptable competency in the realism of information and event components, although at low rates, is higher than the other components. Furthermore, compared to textbooks, the number of questions in CASEI with partial sufficient and sufficient competency for each component is higher. This situation shows that, although not at the desired levels, the questions included in exams are closer to reality. The transition to certain prestigious high schools was based on student scores at CASEI, measured reasoning ability and logic within the framework of the PISA and TIMSS assessments. Studies exist in which the core components of contextual realism are demonstrated at varying levels of competency. Palm and Burman (2004) examined the content of Finnish and Swedish upper secondary school national assessments and revealed that these assessments were significantly inadequate in simulating real-life contexts, particularly regarding their purpose and data/information characteristics.

This study elucidates the contextual reality competencies inherent in mathematical problems as presented in mathematics textbooks and high school transition exams. Further research is required to gain a comprehensive understanding of the reflections of the inadequacies identified in this study on teachers and students. Additionally, intervention studies to enhance the contextual relevance levels of the problems will contribute to the existing literature on this topic. It is also recommended that research be conducted to examine the reflections of the competencies related to contextual realism in different curriculum resources.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

I/We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 286-303
doi: 10.24106/kefdergi.1683452

| Research Article / Araştırma Makalesi |

Design, Implementation, and Evaluation of Remote Mentoring Practices for Technology Integration in Higher Education

Yüksek Öğretimde Teknoloji Entegrasyonuna Yönelik Uzaktan Mentörlük Uygulamalarının Tasarlanması, Uygulanması ve Değerlendirilmesi

Asiye Pınar KÖKSAL TOPCU[1]

Keywords
1. Mentoring
2. Technology
3. Integration
4. Framework
5. TPACK

Anahtar Kelimeler
1. Mentörlük
2. Teknoloji
3. Entegrasyon
4. Çerçeve
5. TPACK

Received/Başvuru Tarihi
13.10.2024

Accepted / Kabul Tarihi
14.04.2025

Abstract

Purpose: This study aims to support the development of faculty members in higher education who implement student-centered learning approaches by providing mentoring support for technology integration. The study also aims to assess the effects of these practices on both the faculty members and the teacher candidates attending their classes and to evaluate their applicability under the conditions of our country.
Design/Methodology/Approach: This study used a case study method, and data collection tools included observations, reflections, interviews, and lesson videos. The faculty members in higher education were mentored for 13 weeks, their lessons were followed, and observations were made on both the mentee and their students. The mentor wrote weekly reflections throughout the process, and lesson observations were recorded on an observation form. At the end of the process, the mentee was interviewed. Content analysis was used for data analysis.

Findings: During the study, a framework for remote mentoring for technology integration was designed and implemented, considering the TPACK framework. The study's results indicated that remote mentoring practices for technology integration in higher education positively influenced in-class teaching practices. In the following weeks, technology was actively used by both the mentee and the students, with careful attention given to digital materials and tools. Student groups also applied the practices provided during the mentoring process in their lesson presentations.

Highlights: Based on the positive findings, this research underscores the significance of mentoring practices for technology integration in higher education.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, öğrenci merkezli öğrenme yaklaşımlarına dayanan öğretim programlarını uygulayacak yüksek öğretimde görevli öğretim elemanına teknoloji entegrasyonuna yönelik mentörlük desteği vererek onun gelişimini desteklemek ve bu uygulamaların hem öğretim üyesinde etkisini hem de dersine giren öğretmen adayları üzerindeki etkilerini, ülkemiz koşullarında uygulanabilirliğini ortaya koymaktır.

Materyal ve Yöntem: Bu çalışmada yöntem olarak durum çalışması, veri toplama aracı olarak da gözlemler, yansılar, görüşmeler ve ders videoları kullanılmıştır. Çalışma da yüksek öğretimde görevli öğretim üyesine 13 hafta boyunca mentörlük yapılmış, menteenin dersi takip edilmiş ve hem mentee hem de öğrencileri üzerinde gözlemler yapılmıştır. Süreç boyunca mentör tarafından her hafta için yansı yazılmış, ders gözlemleri oluşturulan gözlem formuna ayrıca not edilmiştir. Süreç sonunda ise mentee ile görüşme yapılmıştır. Verilerin analiz edilmesinde içerik analizi kullanılmıştır.

Bulgular: Çalışma sürecinde teknoloji entegrasyonuna yönelik uzaktan mentörlük için TPACK çerçevesi dikkate alınarak bir çerçeve tasarlanmış ve uygulanmıştır. Çalışmanın sonunda yüksek öğretimde teknoloji entegrasyonuna yönelik uzaktan mentörlük uygulamalarının sınıf içi öğretim uygulamalarının olumlu etkilediği, ilerleyen haftalarda teknolojiyi menteenin ve öğrencilerin aktif bir şekilde kullandığı, dijital materyal ve gereç kullanmaya özen gösterildiği, öğrenci gruplarının mentörlük sürecinde verilen uygulamaları kendi ders anlatımında kullandığı sonucuna ulaşılmıştır.

Önemli Vurgular: Olumlu bulgulara dayanarak, bu çalışma, yükseköğretimde teknoloji entegrasyonu için mentörlük uygulamalarının önemini vurgulamaktadır.

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Citation/Alıntı: Köksal-Topcu, A. P. (2025). Design, Implementation, and Evaluation of Remote Mentoring Practices for Technology Integration in Higher Education, *Kastamonu Education Journal, 33*(2), 286-303. doi: 10.24106/kefdergi.1683452

INTRODUCTION

It is as essential for teachers, the most crucial part of the education system, to adapt to innovations (new teaching approaches, technological and scientific developments, etc.) during their careers as it is to enter the profession well-prepared. In this context, it is believed that it is essential for teacher educators to adopt new teaching approaches and to keep up with technological developments in education (Akdeniz & Paliç, 2012; Can, 2004; Kuloğlu & Akpınar, 2016). In a world that is constantly renewing and evolving, the biggest challenge developing countries face is the difficulty in improving educational activities to keep up with the globalizing world (Habacı, Karataş, Adıgüzelli, Ürker & Atıcı, 2013). Since a qualified student profile, which any country would wish to achieve, can only be ensured by high-quality teachers and faculty members, the continuously changing understanding of teacher training policies has negatively affected teacher quality. As a result, the desired productivity has not been achieved (Azar, 2010). It is suggested that to achieve the desired productivity in education, it is essential to move toward standardization by determining competencies in teacher training (Arslan, 2008). Accordingly, various methods exist to help teacher educators integrate technology into their lessons, and in developed countries, mentoring practices are employed to support educators.

Mentoring is the process in which an experienced educator provides assistance, support, guidance, and advice to help the professional development of their colleagues (Sullivan, 2000). Historically, mentoring has its roots in Greek mythology (Bakioğlu, 2015; Kılıç & Serin, 2017). The term "mentor" was first used in 17th-century France in the books of Fenelon, who taught the grandson of Louis XIV (Mueller, 2004; Kuzu, Kahraman & Odabaşı, 2012). In the Anatolian region, the concept of mentoring appeared as "atabeg" during the Seljuk period and as "lalalık" or "ahilik" in the Ottoman era (Kahraman, 2012).

In mentoring terminology, the person providing support is called the "mentor," while the person receiving support is called the "mentee," "menti," or "service recipient." A mentor acts as a guide, consultant, advisor, or leader, sharing their skills and experiences with less experienced individuals in their field (Aslan & Odabaşı, 2013; İlhan, 2013; Yirci, 2009). According to İlhan (2013), Kram, and Isabella (1985), a mentor is an expert in a particular field who provides participants with emotional and professional support by sharing their experience and knowledge. The mentee is defined as someone who seeks to develop their skills and needs the guidance of a more experienced colleague (Yirci & Kocabaş, 2012).

The mentor and mentee must harmonize their responsibilities for a successful mentoring process. This harmony ensures an effective and productive mentoring process, where knowledge and experience are continuously transferred throughout the process, and the desired goals are achieved (Kartal et al., 2017). In the mentor-mentee relationship, mutual respect and trust are crucial; the mentor should identify the mentee's problem areas and meet their needs, act as a role model, and encourage them to make their own decisions. It has also been found that humor and laughter positively influence the mentoring process, enhancing interaction between mentor and mentee and reducing the mentee's fear and anxiety (Bakioğlu, 2015).

To ensure a quality mentoring process, it is necessary to identify the characteristics of both mentor and mentee. A good mentor should possess qualities such as experience, patience, flexibility, creativity, planning, commitment to the process, willingness to help, communication skills, openness to learning, empathy, clear goals and objectives, relationship management skills, adherence to ethical standards, up-to-date knowledge, and the ability to provide effective feedback (Clasen & Clasen, 1997; Çakır, 2015; Daresh, 2003; Kahraman, 2012; Klasen & Clutterback, 2002; Yirci, 2009). Similarly, a good mentee should be ready for the mentoring relationship, eager to learn, organized, communicative, willing to share, and optimistic (Clutterbuck, 2014; Kahraman, 2012; Rowley, 1999).

Figure 1 shows the responsibilities of both mentee and mentor, the key elements of the mentoring process (Bakioğlu, 2015).

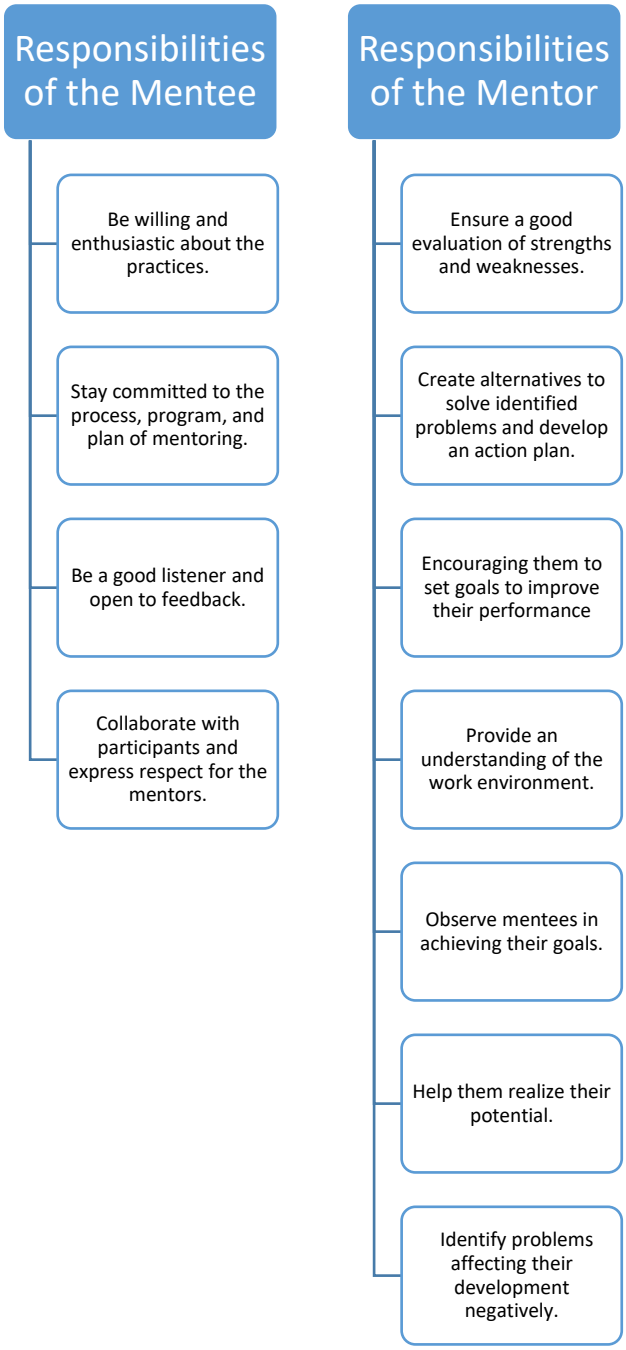

Figure 1. Responsibilities of the Mentee and Mentor

In the study, considering all these characteristics, a mentoring contract was signed between the mentee and mentor at the beginning of the process, and remote mentoring practices for technology integration were initiated.

Remote Mentoring for Technology Integration

The use of technology, especially in the teaching and learning process within the education system, has gained significant importance in recent years. Information and communication tools are widely used in preschool and primary education institutions as well as secondary and higher education institutions. The use of technology in education mentioned here refers to using technological tools in lessons and integrating technology into the teaching and learning process. Technology integration refers to the interdisciplinary application of instructional technology across all curriculum areas in appropriate and meaningful ways (Yirci, 2009). In other words, technology integration aims to select and use the appropriate technology relevant to the content to achieve the set objectives, thereby ensuring effective learning. Various methods are being tried to achieve this goal, and mentoring practices are included to support educators. The primary purpose of mentoring is to facilitate the participant's

learning and development (Brockbank & McGill, 2006). While the mentoring process is typically defined as the process where more experienced individuals assist less experienced individuals, within the scope of this study, the mentor supports the mentee's development by providing mentoring support focused on technology integration. The mentoring was conducted remotely. Remote mentoring is one of the best methods that can be used in situations such as the pandemic period we experienced in recent years. Remote mentoring involves managing the mentoring process independently of time and space using information and communication technologies such as email, computer, and web tools (Bierema & Merriam, 2002). In this regard, it can be said that this was one of the most suitable types of mentoring for this period.

Within the study, a framework for remote mentoring focused on technology integration was designed. The framework was developed with consideration of the TPACK framework.

Remote Mentoring Practices Focused on Technology Integration with Consideration of the TPACK Framework

Technological Pedagogical Content Knowledge (TPACK) contributes to how an educator transforms technological tools into pedagogical strategies and content representations for teaching a specific subject and how these affect student learning (Graham et al., 2009). TPACK is a framework that focuses on the intersection of content, pedagogy, and technology knowledge in technology integration (Abbitt, 2011) and explains teachers' understandings of how these knowledge domains can interact (Harris et al., 2009).

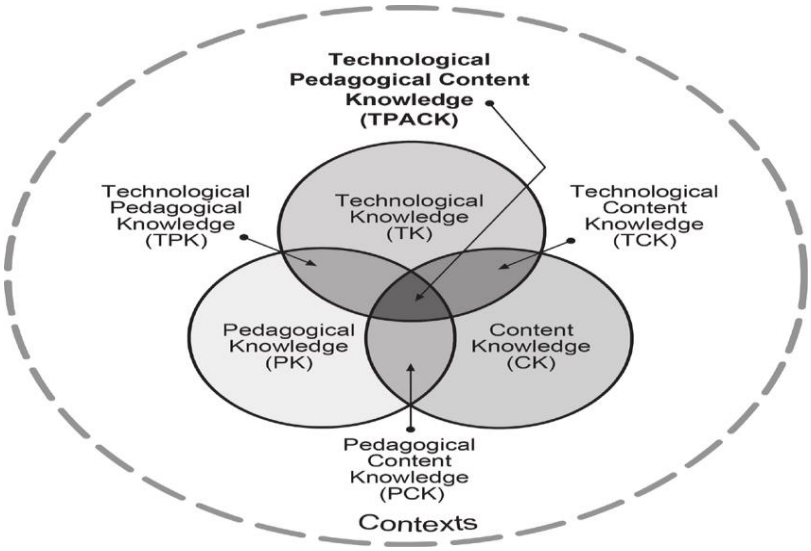

Figure 2. Scope of Technological Pedagogical Content Knowledge (TPACK)

The TPACK theoretical framework is based on the idea that teacher knowledge necessary for teaching in technology-rich environments derives from three sources: content knowledge, pedagogical knowledge, and technological knowledge. It focuses on the relationships and interactions between these components. In this context, the TPACK framework identifies seven knowledge domains that teachers should possess to integrate technology into teaching: Content Knowledge, Pedagogical Knowledge, Technological Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge (Agyei & Voogt, 2012; Koehler & Mishra, 2008). The TPACK theoretical framework, which is considered a useful framework to support technology integration in educational practices (Horzum, 2013), has been of interest since the day it was first put forward, as it has been a pioneer in the effective integration of technology into education (Baran & Canbazoğlu Bilici, 2015) and provides information on how teachers should use technology in the correct proportion and efficiently in the learning process (Handayani et al., 2023). Considering the TPACK framework is crucial in mentoring practices focused on technology integration.

Purpose of the Study

The purpose of this study is to support the development of faculty members in higher education who implement student-centered learning approaches by providing mentoring support for technology integration and to evaluate the effects of these practices on both the faculty members and the teacher candidates attending their classes, as well as their applicability under the conditions of our country. In line with this purpose, the following research questions were addressed:

1. How do technology integration-focused mentoring practices affect faculty members' in-class teaching practices?
2. How do technology integration-focused mentoring practices affect the mentee's technological competencies?

3. What are the effects of mentoring practices on the students?

4. How does the mentee evaluate the mentoring practices focused on technology integration?

It is hoped that this study will contribute to the literature by increasing the technology competence of faculty members, improving classroom teaching practices, and exploring the positive aspects of these effects on students through mentoring practices focused on technology integration, by taking into account the TPACK framework.

METHOD/MATERIALS

This study, which aims to support the development of faculty members in higher education by providing mentoring support for technology integration and to assess the impact of these practices on faculty members and the teacher candidates attending their classes, was conducted using a case study method. A case study is a methodological approach that involves an in-depth examination of a system by collecting systematic data through multiple methods to understand how the system operates (Chmiliar, 2010). Merriam (2013) defines a case study as an in-depth description and analysis of a bounded system. Meanwhile, Creswell (2007) describes a case study as a qualitative research approach where the researcher investigates one or more bounded cases over time through in-depth data collection involving multiple sources of information (observations, interviews, audiovisuals, documents, reports).

Profile of Mentee, Mentor, and Students

Information was gathered about the mentee, who serves as a lecturer in higher education, focusing on their research areas: students' self-regulation skills in homework, teachers' homework practices, students' perceptions of learning environment goals, personal goal orientations, and variables related to learning, as well as STEM education. Based on this, a list of potential mentoring services was created and shared with the mentee.

It was ensured that the mentor had the technological competence to be able to mentor and it was checked whether he/she had received sufficient training in this regard. The mentor's areas of training include Basic Robotics Course, Robotics and Software Education, STEM Education, Coordination and Program Development Training, Astronomy Education and Applications, Brain Games Training 1-2, Writing Activities for Learning Purposes, Quantitative Research Methods, Qualitative Research Methods, Mixed Research Methods, Augmented Reality Applications, and AppInventor applications. The mentor has also been a project manager, trainer, workshop leader, and consultant in numerous projects. These areas of education and interest were shared with the mentee to help the mentee gain insights and explore alternative aspects where they could receive mentoring support.

The student profile comprises 20 students taking the Instructional Principles and Methods course. Since this is a graduate-level course, the students come from different disciplines.

Stages of Technology Integration Application

The implementation of mentoring to the mentee in this study is outlined in the stages below:

I. Stage: Preparation

Table 1 explains the structure of the preparation stage, which was deemed necessary for revealing the mentoring framework to be developed.

Table 1. Preparation Stage

Preparation Stage		
Introduction-Observation-Evaluation	**Preparation Phase Feedback and Guidance**	**Setting Objectives and Goals**
• Collecting information about the mentee • Communication and introduction between mentor and mentee • Observation of the lesson related to the mentee • Identifying needs • Signing the mentoring agreement	• Based on initial observations and data obtained from discussions with the mentee, determining what the mentee needs in terms of technology and mentoring Placing the practices required for those needs • Continuing meetings with the mentee regarding these practices and making summaries and directives mainly by the mentor	• Setting objectives • Creating a plan • Finalizing the plan by creating the final version of the Work Calendar

II. Stage: Implementing Mentorship

This study carried out this stage over thirteen weeks, consisting of weekly regular sessions for the mentee and parallel classroom observations conducted in conjunction with these sessions. The steps of the Implementation stage, the second phase of the study, are outlined in Figure 3.

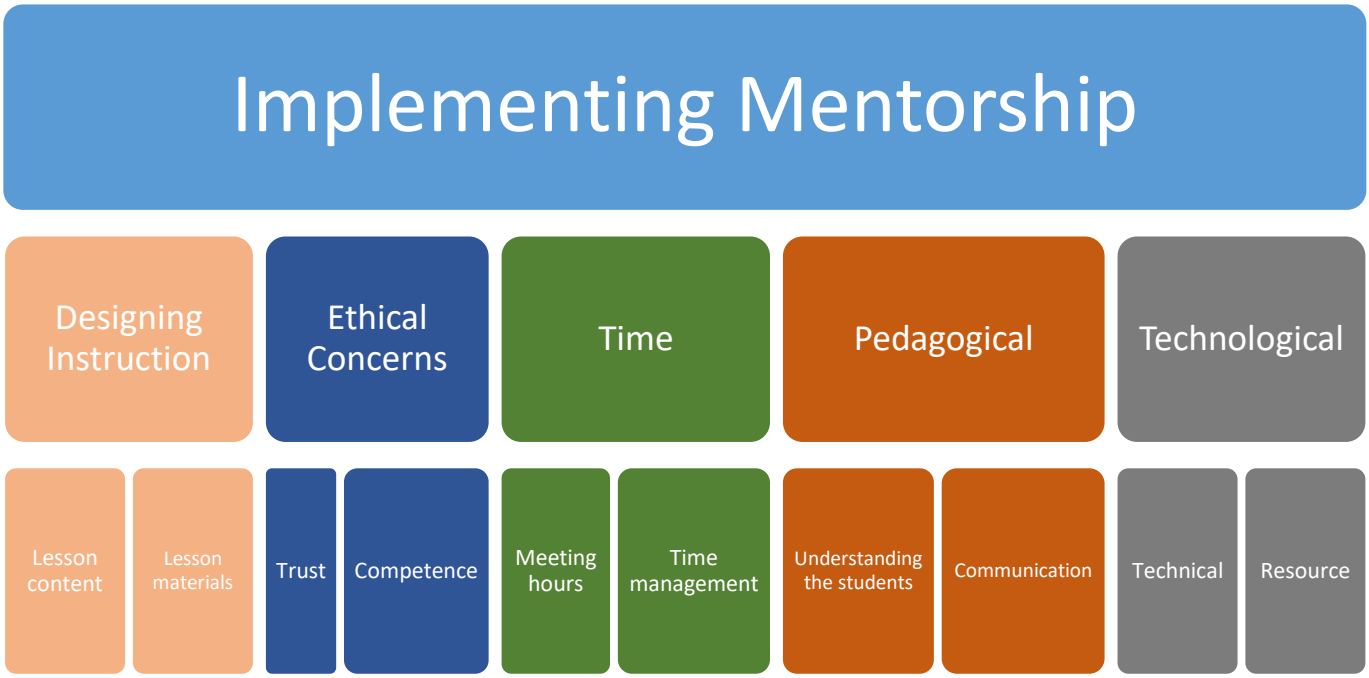

Figure 3.Implementing Mentorship

The TPACK framework was utilized in instructional design, pedagogy, and technology, especially at this stage.

III. Stage: Overall Evaluation

This study stage aimed to evaluate the effects of the mentoring framework developed during the study. The goal was to support the development of a higher education faculty member by providing mentoring support focused on technology integration and to investigate the impact of these practices on both the faculty member and the teacher candidates in their classes. The evaluation was done through class observations (in the mentee's Instructional Principles and Methods course), video recordings of the lessons, weekly reflections, and interviews.

Type of Mentoring Implemented: Remote Mentoring

In the study, the mentor and mentee conducted mentoring sessions on predetermined days and times each week. The mentoring practices were carried out remotely. Remote mentoring is managing the mentoring relationship independently of time and location using information and communication technologies such as email, computers, and web tools (Bierema & Merriam, 2002). Tools such as email, Zoom, WhatsApp, and phone calls were used within this framework. Additionally, reverse mentoring was employed in this study. In typical mentoring, the mentor is usually older than the mentee. However, in this study, the mentor was younger than the mentee. Reverse mentoring is often conducted for mentees who need assistance with technology, such as using computers or the Internet (Kahraman, 2012). In this study, the remote mentoring process generally progressed as follows:

After the mentor and mentee were introduced, the process began with identifying the applications for which the mentee needed mentoring support in technology based on initial observations and interviews with the mentee.

Discussions with the mentee continued about these applications, with the mentor providing summaries and guidance. Plans were made and finalized, and a work schedule was created. Each week, the mentor and mentee conducted mentoring sessions on the agreed-upon days and times, with the process carried out according to the plan and schedule. The mentoring sessions introduced various technological applications over 13 weeks. A period of 13 weeks was determined because it would take a long time to both increase an individual's technological competence and observe the effects of this competence.

Before each mentoring session, the mentor emailed the mentee worksheets prepared by the mentor. This ensured that the mentee understood the applications and could come prepared for the sessions.

Data Collection Tools

The data collection tools used in the study included observations, reflections, interviews, and lesson videos. Participants were informed at each scale and confidentiality was taken into account.

Observations and Videos of the Mentee's Instructional Principles and Methods Course

Over 13 weeks, the mentee's Instructional Principles and Methods lessons were observed, and video recordings were made to confirm the observations. The focus was on whether the mentoring practices were integrated into the lessons, the effects of technology integration-focused mentoring on the mentee's technological competencies (e.g., effective use of technology in lessons, designing or selecting technology-based materials), the impact on students, and whether students applied this integration in their presentations following the mentee's lessons. The mentor noted the observations using an observation form. Each week, behaviors were marked with an 'X' if performed and left unmarked if not. Additionally, weekly reflections were written by the mentor and recorded. The mentor took on a neutral observer role during the observations, taking notes and monitoring technical issues without intervening in the lessons, and later transcribed the observation results. The observation data were analyzed by the researcher at two different times and were also analyzed by a second researcher. While the agreement between the analyses made by the researcher at different times was found to be 85%, the agreement between the analyses made by the two researchers (Kappa Coefficient) was found to be 72%

Weekly Reflections

The activities carried out each week with the mentor and mentee according to the work schedule, the observations of the mentee's Instructional Principles and Methods course, and the overall evaluation of the process were recorded in the weekly reflections kept by the mentor. These reflections were used to summarize each week's activities, provide a detailed review of the process, and help answer the research questions. A second researcher was asked to analyze the reflection data.

Semi-Structured Interviews

At the end of the mentoring process, semi-structured interviews were conducted with the mentee to gather their views on the effects of technology integration-focused mentoring practices on their classroom teaching practices (e.g., student-centered teaching, using different methods, classroom management, communication with students, providing guidance, dealing with problems), on their technological competencies (e.g., effective use of technology in lessons, designing or selecting technology-based materials), the impact of mentoring on students, and the roles and changes in roles during the mentoring sessions. The mentee's responses were transcribed**.** The interview data were analyzed by the researcher at two different times and were also analyzed by a second researcher. While the agreement between the analyses made by the researcher at different times was found to be 90%, the agreement between the analyses made by the two researchers (Kappa Coefficient) was found to be 82%.

Data Analysis

Content analysis was used to analyze the data. Weekly reflections and interview data were analyzed descriptively using content analysis methods. In content analysis, the data is classified and examined within the framework of specific themes. After several readings, codes are created, and similar codes are grouped under appropriate categories (Yıldırım & Şimşek, 2006).

FINDINGS

Designing and Implementing the Framework of the Mentoring Process (Preparation - Implementation - Overall Evaluation)

From a broad perspective on the functions of mentoring, it is concluded that mentoring practices positively affect the individual, professional (academic), and career development of the mentee. It has been noted that the technology integration approach has been emphasized recently in mentoring. The mentoring process in this study began with an introduction and needs assessment, followed by a mentoring contract. For the mentoring practices to achieve the desired level of quality, the relationship between mentor and mentee must be clearly defined. A successful mentor must possess listening, motivation, influence, evidence collection, collaboration, consulting, time management, and professional development skills. In mentoring

practices, the mentor's role includes guiding the mentee, answering questions, developing the mentee's skills, maintaining long-term interaction, providing observation and feedback, offering personal support, serving as a role model, improving academic achievement and expectations, fostering effective and lasting learning, and contributing to professional development. This process was completed with the mentoring contract. Goals were then set, and a work schedule was created. Technological resources were identified, and the mentor attended the mentee's classes to assist in achieving TPACK proficiency and provide pedagogical support while getting to know the students.

Throughout the process, mutual information exchange occurred between the mentor and mentee, with the mentor demonstrating essential skills in helping the mentee set goals and supporting the mentee through practical applications.

For a successful mentoring process and to alleviate ethical concerns, the mentor and mentee must harmonize their responsibilities. This harmony ensures an effective and productive mentoring process, with the desired goals being achieved and the transfer of knowledge and experience between the mentor and mentee continuing throughout the process.

Furthermore, the mentor and mentee must fulfill their roles and responsibilities because these duties contribute to a higher-quality, goal-oriented, and ethical mentoring process. Mentoring practices provide both the mentor and mentee with professional and personal development opportunities. These areas of development or functions are categorized as career and psychosocial functions. Finally, feedback is crucial in the mentoring process, and necessary precautions are taken to ensure that feedback is provided effectively and the process is evaluated.

Considering these processes, a general framework for designing, implementing, and evaluating remote mentoring practices for technology integration in higher education was developed and created, as shown in Figure 4.

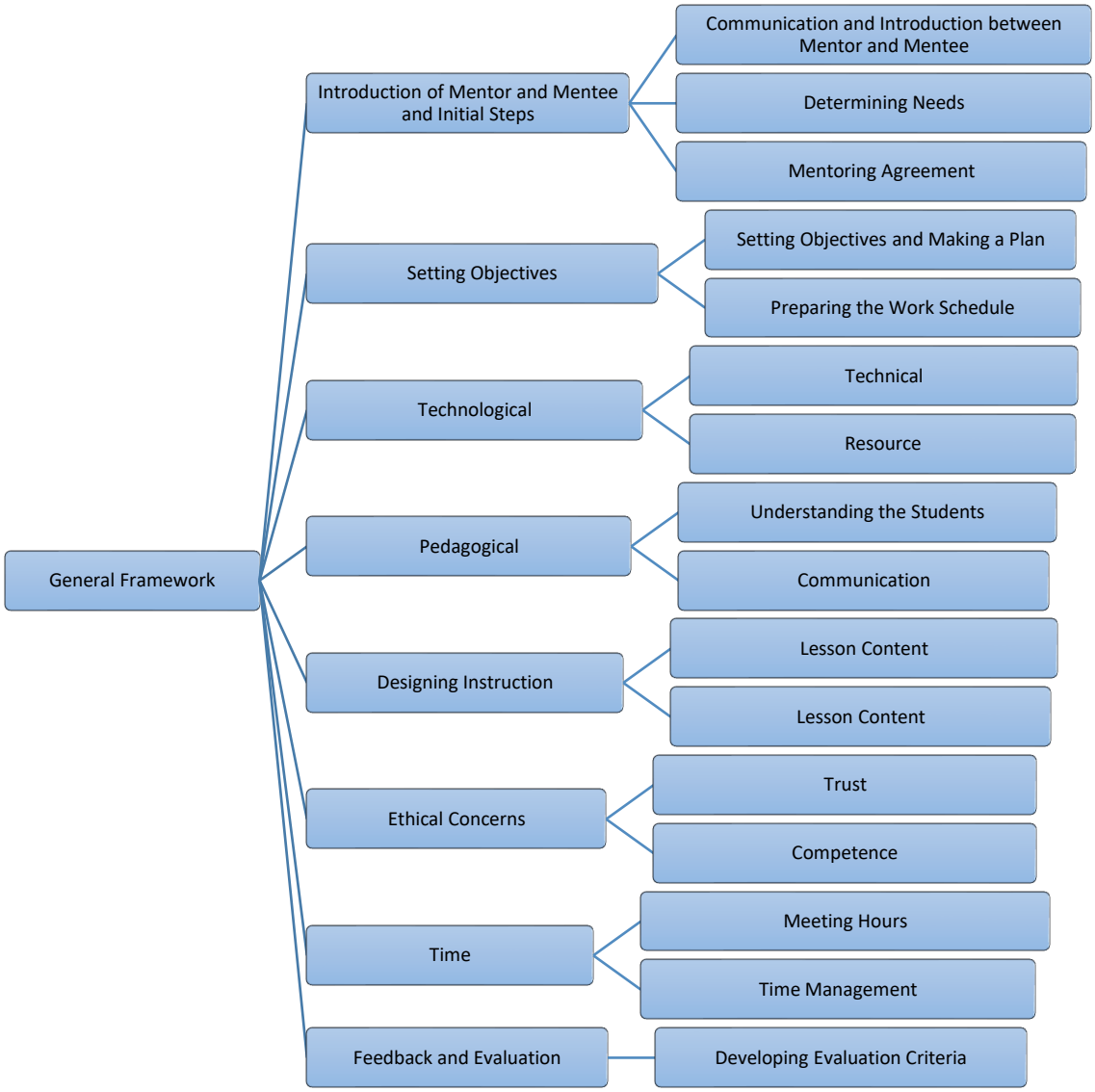

Figure 4. General Framework of the Mentoring Process Designed within the Study

The general framework depicted in Figure 3, created as part of the study, consists of eight sub-dimensions: mentor-mentee introduction and first steps, goal setting, the technological, pedagogical, and instructional design dimensions based on the TPACK framework, ethical concerns throughout the entire process, time management, and feedback-evaluation. Initially, the mentor contacted the mentee, and the introduction took place. The mentoring sessions began with the mentor identifying the technical and technological needs of the mentee, during which the mentor provided suggestions. With the mentee's consent, a mentoring contract was signed, and a work schedule was created based on the agreed-upon topics. Since the goal was to achieve technology integration, the TPACK framework was considered, integrating technological, pedagogical, and content knowledge into the work schedule. During the mentoring sessions, the mentor and mentee introduced technological resources weekly, and by following the mentee's Instructional Principles and Methods class, the mentor had the opportunity to observe and become familiar with the students, examining the process's impact on the mentee's lessons in terms of technology, pedagogy, and content. Throughout the process, in the dimension of ethical concerns, the mentor fulfilled their responsibilities toward the mentee, establishing a mutual trust. Efforts were made to adhere to the meeting schedules, ensuring attention to time management. The mentee provided feedback and evaluations to the students during the process, with assessments conducted using the scale from the work schedule in the first week.

Effects of Technology Integration-Focused Mentoring Practices on the Faculty Member's In-Class Teaching Practices

At this study stage, the mentor attended the mentee's remotely conducted Instructional Principles and Methods course for nine weeks, with observations for the four missed classes made through viewing the recorded lesson videos. The observations were noted on an observation form created by the mentor. Each week, if the observed behaviors were present, they were marked with an 'X'; if not, no mark was made. Additionally, throughout the 13 weeks, lesson observations were recorded in the mentor's reflections.

In the study, behaviors such as implementing the lesson plan, keeping students mentally engaged, guiding students in accessing information, allowing students time for responses and explanations, listening to them and providing feedback, using technological applications introduced during the mentoring process in class, employing different technological methods, and using both traditional and performance-based assessment tools were identified in the observation form created to investigate the effects of technology integration-focused mentoring on the faculty member's in-class teaching practices. These behaviors were observed over 13 weeks, and their occurrence frequency (the total number of weeks they were observed) and percentage (the percentage of weeks the behavior was observed out of 13) are presented in Table 2.

Table 2 . Observation Findings on the Effects of Technology Integration-Focused Mentoring Practices on the Faculty Member's In-Class Teaching Practices

Observed Behavior	Gözlem Haftası	Frekans (1-13 hafta)	Yüzde %
Implementing the lesson plan	W1, W 2, W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13	13	100
Keeping the student mentally active	W4, W5, W6, W7, W8, W9, W10, W11, W12, W13	10	76,92
Guiding the student in the process of accessing information	W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13	11	84,61
Allowing time for students to ask questions and explanations, actively listening and provide feedback	W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13	11	84,61
Using technological applications provided in the mentoring process during the lesson	W5, W6, W7, W8, W9, W10, W11, W12, W13	9	69,23
Using different technological methods	W5, W6, W7, W8, W9, W10, W11, W12, W13	9	69,23
Using traditional and performance-based measurement and evaulation tools together	W1, W2, W3, W4, W5, W6, W7, W8, W9, W10, W11, W12, W13	13	100

(W= Week, for example W4= Observation related to Week 4)

According to Table 2; implementing the lesson plan, keeping the student mentally active, guiding the student in the process of accessing information, giving students time for answers and explanations, listening to them and giving feedback, using technological applications given during the mentoring process in the lesson, using different technological methods, traditional and performance-based assessments. While the lowest observation frequency of behaviors such as using assessment tools together was observed to be 9 in 13 weeks, behaviors such as implementing the lesson plan and using traditional and performance-based measurement-evaluation tools together were observed in all weeks.

The mentoring sessions and studies carried out with the mentor and mentee every week in accordance with the work schedule, observations of the effects of these studies on the mentee's Teaching Principles and Methods course, and the general evaluation of the process were recorded in the reflections kept by the mentor for 13 weeks.

In the study, for the first research question, which was to investigate the effects of technology integration-oriented mentoring practices on the faculty member's classroom teaching practices, weekly reflections were examined along with observations, and certain themes and categories were created from the reflections and the reflection weeks and frequencies were found as in Table 3.

Table 3. Observational Findings Regarding the Effects of Technology Integration-Focused Mentoring Applications on Classroom Teaching Practices

Theme	Category	Frequency (1-13 weeks)	Total
Effect of Technology Integration-Focused Mentoring on Classroom Teaching Practices	Providing suggestions for the use of technology by students	7	**71**
	Acting as a role model in using technology for students	6	
	Keeping students mentally active	10	
	Guiding students in accessing information	11	
	Using technological applications provided during mentoring in the lesson	9	
	Intervening in problems and difficulties encountered	13	
	Using different technological methods	9	

According to Table 3, eight categories were created under the theme of the effects of technology integration-focused mentoring on in-class teaching practices. The categories are as follows: providing students with suggestions on using technology, giving positive reinforcement to students who use appropriate digital materials in their presentations, being a role model for students in using technology, keeping students mentally engaged, guiding students in the process of accessing information, using the technological applications introduced during the mentoring process in the lessons, addressing problems and challenges encountered, and employing different technological methods.

Effects of Technology Integration-Focused Mentoring Practices on the Mentee's Technological Competencies

The study identified behaviors such as effectively using technology in the lesson, designing and selecting technology-based materials, and using digital materials and tools in the observation form created to investigate the effects of technology integration-focused mentoring on the mentee's technological competencies. These behaviors were observed, and the frequency (the total number of weeks they were observed) and percentages (the percentage of weeks the behavior was observed out of 13) were recorded, as shown in Table 4.

Table 4. Observation Findings on the Effects of Technology Integration-Focused Mentoring Practices on the Mentee's Technological Competencies

Observed Behavior	Observation Week	Frequency (1-13 weeks)	Percentage (%)
Effective use of technology in the lesson	W5, W6, W7, W8, W9, W10, W11, W12, W13	9	69.23
Designing and selecting technology-focused materials	W5, W6, W7, W8, W9, W10, W11, W12, W13	9	69.23
Using digital materials and tools	W6, W7, W8, W9, W10, W11, W12, W13	8	61.53

According to Table 4, the behaviors identified, such as effectively using technology in the lesson, designing and selecting technology-based materials, and using digital materials and tools, were generally observed starting from the fourth week of the mentoring process. The behaviors of effectively using technology in the lesson and designing and selecting technology-based materials were observed for nine weeks (69.23%) out of the 13 weeks, while using digital materials and tools was observed for eight weeks (61.53%).

The second research question, which aimed to investigate the effects of technology integration-focused mentoring practices on the mentee's technological competencies, was examined through weekly reflections and observations. Themes and categories were derived from the reflections, and their frequencies were determined, as shown in Table 5.

Table 5. Findings from Reflections on the Effects of Technology Integration-Focused Mentoring Practices on the Mentee's Technological Competencies

Theme	Category	Frequency (1-13 weeks)	Total
Effect of Technology Integration-Focused Mentoring on the Mentee's Technological Competencies	Applying the information obtained from mentoring sessions the following week	9	
	Performing technology-based tasks assigned by the mentor	6	
	Being able to implement the applications during mentoring sessions	6	
	Effective use of technology in the lesson	9	**47**
	Designing and selecting technology-focused materials	9	
	Using digital materials and tools	8	

According to Table 5, the analysis resulted in six categories under the theme of the effect of technology integration-focused mentoring on the mentee's technological competency. These categories include applying the knowledge gained from the mentoring sessions the following week, completing technology-based tasks assigned by the mentor, performing technological applications during the mentoring sessions, effectively using technology in the lesson, designing and selecting technology-based materials, and using digital materials and tools.

Effects of Mentoring Practices on Students

In the study, the observation form was created to investigate the effects of mentoring practices on students' identified behaviors, such as student groups incorporating the technological applications introduced during the mentoring process into their lesson presentations and emphasizing digital materials and tools. These behaviors were observed, and the weeks they were observed, along with their frequencies and percentages, are presented in Table 6.

Table 6. Observational Findings Regarding the Effects of Mentoring Applications on Students

Observed Behavior	Observation Week	Frequency	Percentage (%)
Use of applications given during mentoring by student groups presenting lessons in their lesson presentations	W8, W9, W10, W11, W12, W13	6	46.15
Drawing attention to the use of digital materials and tools	W6, W7, W8, W9, W10, W11, W12, W13	8	61.53

According to Table 6, the behaviors identified, such as student groups incorporating the technological applications introduced during the mentoring process into their lesson presentations and emphasizing digital materials and tools, generally started being observed from the sixth week of the mentoring process. Incorporating the technological applications introduced during the mentoring process into their lesson presentations were observed for six weeks (46.15%) while emphasizing the use of digital materials and tools was observed for eight weeks (61.53%) based on the observations.

The second research question, which aimed to investigate the effects of mentoring practices on students, was examined through weekly reflections and observations. Themes and categories were derived from the reflections, and their frequencies were determined, as shown in Table 7.

Table 7. Findings from Reflections on the Effects of Mentoring Practices on Students

Theme	Category	Frequency	Total
Effects of Mentoring Applications on Students	Emphasizing the use of technology in lesson presentations	7	27
	Correctly integrating technology	6	
	Use of applications provided during mentoring by student groups presenting lessons in their presentations	6	
	Use of digital materials and tools	8	

Based on the analysis of Table 7, four categories were created under the theme of the effects of mentoring practices on students: emphasizing the use of technology in lesson presentations, properly integrating technology, student groups incorporating the technological applications introduced during the mentoring process into their lesson presentations and using digital materials and tools.

Evaluation of Technology Integration-Focused Mentoring Practices by the Mentee (Findings from Semi-Structured Interviews)

Following the mentoring practices, this study conducted a semi-structured interview with the mentee to gather their views on various aspects. These included the effects of technology integration-focused mentoring practices on the mentee's in-class teaching practices (such as conducting student-centered lessons, applying different methods, classroom management, communicating with students, providing guidance, etc.), the effects on the mentee's technological competencies (such as effectively using technology in lessons, designing and selecting technology-based materials), the effects of mentoring practices on students, the impact of roles and role changes during the mentoring sessions, and challenges experienced during the mentoring process. The mentee's responses were analyzed, and themes, categories, and codes were created, as shown in Table 8.

Table 8. Mentee's Views on Technology Integration-Focused Mentoring Practices

Theme	Category	Code	Total	Code
Evaluation of mentoring practices focused on technology integration by the mentee	Effect of classroom applications	Establishing effective communication	4	
		Providing guidance		
		Conducting student-centered lessons		
		Using in other lessons		
	Effect of Technological Competencies	Being competent in technology	4	
		Using applications		
		Sharing ideas on selecting and designing materials		
		Using applications		
	Effect of mentoring applications on students	Integrating applications into students' presentations	5	
		Giving suggestions		
		Sharing worksheets		
		Being more active in class		
		Integrate them into their own fields		
	Effect on the change of roles between mentor and mentee	Mutual learning	5	
		Seeing progress		
		Involving students in the process		
		Moving from the role of mentee to the role of mentor		
		Being positively affected by change		
	Difficulties experienced during mentoring	Difficulty due to students not being able to adapt in the first weeks	2	
		Difficulty in conducting lessons remotely		

In the theme of the mentee's evaluation of technology integration-focused mentoring practices, five categories were created based on the mentee's responses through content analysis: the impact on in-class practices, technological competencies, students, roles and role changes during the mentoring process, and challenges faced during the mentoring process.

In the interview with the mentee, when asked, "What are the effects of technology integration-focused mentoring practices on your in-class teaching practices?" the mentee expressed:

"*I tried to apply the mentoring support I received, for example, the following week. Even if I cannot apply some very effectively now, I can apply them in more suitable lessons next year. For instance, I tried using ChatterPix, but I will use it in a Science course I teach next year. I try to conduct my in-class practices student-centered, even though this semester has been greatly affected… It has also been effective in communication, allowing students to open their microphones and speak or write as they wish. I ask questions, and as you know, the student groups assigned in the Instructional Principles and Methods course present each week. We also suggested that they integrate technology into their presentations. The worksheets we sent them had an impact, of course.*"

Based on this response, it was determined that the mentee established effective communication with students, guided them, conducted student-centered lessons, and intended to use the practices in other lessons. Four codes were created based on these responses.

In the interview, when asked, "What are the effects of technology integration-focused mentoring practices on your technological competencies (e.g., effectively using technology in your lessons, designing and selecting technology-based materials)?" the mentee responded:

"I believe our weekly mentoring sessions had an impact on my technological competencies. For example, I had ideas about augmented reality applications before, but I could not put them into practice. Thanks to mentoring, I started to develop ideas about designing and selecting technology-based materials. I am also grateful for the work schedule we created together because the process progressed according to my needs, which made me happy. These were the applications I especially wanted to use in my lessons."

Based on this response, it was determined that mentoring practices positively impacted the mentee's technological competencies, enabled them to implement applications, and helped them form ideas about material selection and design. Four codes were created based on these responses.

When asked, "What are the effects of mentoring practices on your students?" the mentee replied:

"As you know, I conduct the Instructional Principles and Methods course first, and then the class continues with student presentations. First, I will try to implement the technological applications we discussed in our mentoring sessions. As you have seen in the lessons, we suggest that students integrate these applications into their presentations. Sharing the worksheets with them was effective in this process. We observed together that they improved each week. The first groups were only doing passive PowerPoint presentations, but as the weeks progressed, they added applications like video, ChatterPix, and Canva to their presentations. It made us happy that they were more active in class and could integrate these applications into their subject areas."

Based on this response, five codes were created, including integrating applications into student presentations, giving suggestions, sharing worksheets, being more active in class, and integrating them into their fields.

When asked, "What are the effects of roles and role changes during the mentoring sessions?" the mentee stated:

"As we mentioned at the beginning of the process, we said there were many things we could learn from each other. Moreover, yes, that is exactly what happened. Today, I can see our progress thanks to our weekly mentoring sessions. I was the mentee when it came to technology integration. However, sharing my experiences with my students, encouraging them, and including them in the process was almost like transitioning from the role of a mentee to that of a mentor. At this point, I was positively affected by this change. One of the best ways to learn something is to explain it to others."

This response created five codes, including mutual learning, seeing progress, involving students in the process, transitioning from the mentee to the mentor role, and being positively affected by this change.

When asked, "Did you experience any difficulties during the mentoring process? If so, what were they?" the mentee answered:

"We did face some challenges; for example, the students struggled to adapt in the first weeks. You will remember that they only did PowerPoint presentations in the first weeks. However, as time went on, they began to adjust. Also, mentoring remotely was a bit of a challenge... However, aside from that, I did not encounter any major difficulties. We ended up using technology more because of the circumstances. If it had been face-to-face, we might not have used it as much."

Based on this response, two codes were created: students' initial difficulty adapting and the challenge of mentoring remotely.

CONCLUSION, DISCUSSION AND RECOMMENDATIONS

This study aimed to support the development of higher education instructors who implement student-centered learning approaches by providing mentoring support for technology integration. It also examined the effects of these implementations on both the instructor and the pre-service teachers taking their classes and their applicability. The features and content of the mentoring sessions conducted within the scope of the study were designed and implemented based on the actual needs of the mentee and their acceptance of these needs. The technological support applications required by the mentee were identified, and a general mentoring framework was created accordingly. The TPACK framework was mainly considered during the study's implementation phase. The TPACK framework is important because it pioneers the integration of technology into education, provides guidance, and provides information on how to use technology in the best and most efficient way in the learning process. This framework also provides a general overview of the mentoring process from the first stage to the end. It is believed that the framework created within the scope of this study will serve as an example for researchers working on mentoring regarding process management.

According to the results of weekly reflections, semi-structured interviews, and lesson observation forms regarding the first research question of the study – the effects of technology integration-focused mentoring practices on the classroom teaching practices of the instructor (such as conducting student-centered lessons, applying various technological methods, managing the

classroom, communicating with students, providing guidance, addressing problems and challenges, etc.) – it was found that the classroom teaching practices were positively impacted. The instructor implemented such practices in 10 of the 13 weeks, made suggestions to students on integrating them into their presentations, acted as a guide during students' information-seeking process, faced some challenges and the shift to remote education but overcame them over time, and encountered no issues with communication and guidance. The instructor's reinforcement of students who used appropriate digital materials in their presentations and their role-modeling in technology use also positively impacted classroom practices.

In line with Bierema and Meriam (2002), Sockett (1993), Hobson and Maldenez (2010), who found that mentoring practices benefit mentees' professional development, self-assessment, and classroom management, Yost (2002) stated that mentoring practices help instructors meet their needs and develop themselves, which in turn reflects positively on classroom practices and contributes to their student's academic success.

The findings related to the second research question of the study – the effects of technology integration-focused mentoring practices on the technology competencies of the mentee (e.g., effective use of technology in the classroom, designing or selecting technology-focused materials) – indicate that the mentee was able to implement the information gained from mentoring sessions the following week, completed technology-based tasks assigned by the mentor, and showed an inclination towards designing and selecting technology-focused materials during mentoring sessions. Although the mentee did not actively use technology in the first three weeks, the mentee and the students actively used it in the following weeks, paying attention to digital materials and tools.

Considering the efforts made to integrate technology into lesson activities through mentoring sessions and the mentee's dedication to conducting lessons in this manner, it is believed that a diligent process was carried out. Brockbank and McGill (2006) highlighted the importance of mentoring in promoting the mentee's development when assessing this development process. Moreover, Bakioğlu (2015), Clutterbuck (2014), Rowley (1999), and Kahraman (2012) emphasized the importance of qualities such as eagerness to learn, openness to feedback, and planning for mentees. Based on this, it is considered that the mentee had a successful process alongside the mentoring sessions.

Regarding the third research question of the study – the effects of mentoring practices on students – it was observed that after the seventh week, student groups delivering lessons began using the applications provided during the mentoring process in their teaching, the mentee encouraged students to integrate these technological applications into their presentations, and students were more active in class compared to the initial weeks, integrating the applications into their subject areas. Technology integration into student presentations made both the mentee and the mentor happy, and the importance of proper technology integration, rather than merely adding technology, was emphasized during lessons.

Mentoring sessions were designed to support the mentee's transition from traditional teaching activities to student-centered, technology-focused teaching activities in accordance with curriculum requirements. At this point, it was crucial for both the mentee and mentor to fulfill their roles and responsibilities.

According to the semi-structured interview with the mentee regarding the fourth research question of the study – how the mentee evaluated the technology integration-focused mentoring practices – the mentee found the mentoring practices very useful despite the challenges posed. They tried to implement remote mentoring with the mentor and deemed it productive. The mentee also mentioned that both parties learned a lot from each other during the mentoring sessions. After a certain period, when the mentee encouraged their students to integrate these practices into their presentations, they felt they had transitioned from the mentee to the mentor role. The mentee did not face many difficulties during the mentoring practices, except for the challenges posed by remote mentoring and the initial weeks when students had trouble adapting to the process. Reflection and observation results also supported this. For example, it was observed that students did not use technology much in their presentations during the initial weeks. However, in the later weeks, the mentee's active use of technology in the lessons and their suggestions for students to integrate technology into their presentations, along with positive reinforcement from the mentee and other students, showed improvement in technology integration in their presentations.

In this study, special attention was given to developing and using different materials suitable for the individual activities and characteristics of the mentee's students, who were either teacher candidates or teachers (since there were students from other disciplines in this group), supporting teachers in becoming aware of their performance and taking necessary measures accordingly. By enhancing the individual evaluation and control skills of teachers with different characteristics and classroom practices, teachers were encouraged to adapt the example activities provided in the education system to their disciplines and to adopt a problem-solving approach. For example, while science teachers used augmented reality applications for the circulatory system, mathematics teachers preferred them for explaining three-dimensional shapes.

In this study, the necessary information for developing teachers' professional competencies (technology-focused education) was not provided as mere factual knowledge. Instead, teachers were allowed to conduct the required activities (such as interactive short seminars and one-on-one mentoring support) in the presence of a mentor. This support helped the mentee

gain experience preparing such activities (incredibly instructional materials) by actively engaging in the process rather than simply accepting and storing theoretical information about the needed skills. Additionally, the mentee benefited from transferring the experiences gained to their students, thus reaching a wider audience within the scope of the study.

The results of this study parallel those of other research in many respects. Şahinoğlu (2020) evaluated mentoring practices aimed at improving physics teachers' adaptation to the revised curriculum and found that mentoring contributed to both academic and professional development. Needs analyses revealed that teachers tended to adopt more teacher-centered approaches. Alongside the practices, improvements were observed in classroom activities (greeting, motivation, and drawing attention), preparing in-class materials and activities, the didactic structures of their lessons, and student-centered approaches. Moreover, the academic success of students in observed classrooms increased. Mentoring support was found to contribute to the development of teachers. Similarly, Kahraman (2012) investigated the impact of e-mentoring on the professional development of pre-service information technology teachers and found that e-mentoring positively impacted their professional development alongside formal education. The e-mentoring program also facilitated knowledge and experience sharing among students, academics, and graduates, helping to develop social networks. These studies show similarities to this study, supporting the idea that mentoring practices have a positive impact.

Based on the results of this study, which investigated the effects of providing mentoring support for technology integration to higher education instructors and its impact on both the instructor and pre-service teachers taking their classes, as well as the mentor's experiences, the following recommendations are made:

- In this study, reverse mentoring was conducted remotely. Researching the suitability of different mentoring approaches (group, self, one-on-one) for the conditions in our country would support the technology integration process for instructors.

The application of remote mentoring practices to different working groups (such as the training of education administrators, candidates, or formator teachers) would contribute to the effectiveness of studies in these areas.

- Organizing programs and events for instructors who have completed mentoring practices to share their experiences and achievements with their colleagues would enhance the widespread impact of the technology integration process and contribute to the usability of mentoring practices.

- Observing all of the instructor’s lessons, rather than just one or two, during mentoring practices, would allow for a more in-depth needs analysis and result in differentiated mentoring practices that would further support the instructor’s development in technology integration.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

I hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Author contribution statements

The research was prepared by a single author.

Ethics Committee Approval Information

Approving Institution Name: Ataturk University Rectorate- Directorate of the Institute of Educational Sciences Educational Sciences- Science Ethics Committee

Date: 27.05.2022

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 304-321
doi: 10.24106/kefdergi.1683457

| Research Article / Araştırma Makalesi |

A Systematic Review of Research Articles on the Effects of Multiple Intelligences-Based Instruction in Türkiye

Türkiye'de Çoklu zekâ Temelli Öğretimin Etkilerine İlişkin Araştırma Makalelerinin Sistematik Analizi

Özge KARAKUŞ ÖZDEMİRCİ[1]

Keywords
1. Multiple-intelligences theory
2. Multiple-intelligences based instruction
3. Systematic review
4. Türkiye

Anahtar Kelimeler
1. Çoklu zekâ kuramı
2. Çoklu zekâ temelli öğretim
3. Sistematik analiz
4. Türkiye

Received/Başvuru Tarihi
31.01.2024

Accepted / Kabul Tarihi
19.02.2025

Abstract

Purpose: The implementation of Multiple Intelligences (MI)-based instruction holds significant promise for educational advancement, facilitating the pluralization and personalization of pedagogical methods and assessments to engage diverse learners effectively. This study aims to systematically and critically evaluate research articles published on the effects of MI-based instruction from January 2007 to March 2023 within the context of Türkiye, examining their content, objectives, participants, materials, methodologies, outcomes, and publication years.

Design/Methodology/Approach: The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) framework was employed, and 68 research articles were determined using the specified eligibility criteria. A descriptive analysis was conducted to synthesize findings from these studies.

Findings: Findings were discussed through the four predominant themes regarding the effect of MI-based instruction on (1) achievement, (2) attitudes, (3) retention, and (4) teachers' and students' views on the effectiveness of MI-based instruction. The dominance of exam-oriented understanding and the positivist research tradition was quite prominent since the effect of MI-based instruction on achievement was the most studied theme, and experimental design studies were dominant compared to qualitative ones.

Highlights: Findings explicitly revealed the increasing and decreasing attention to the subject and showed inconsistencies between the nature of the theory and methodological choices of studies on MI-based instruction.

Öz

Çalışmanın amacı: Çoklu zekâ temelli (ÇZT) öğretim, her öğrenciye ulaşmak için öğretim yöntemlerinin ve değerlendirmelerin çoğullaştırılması ve kişiselleştirilmesi gibi eğitim için hayati vaatlere sahiptir. Bu nedenle, ÇZ teorisi kısa sürede birçok ülkede, Türkiye'de ise 2000'li yılların başında eğitimde bir trend haline gelmiştir. Bu çalışmanın amacı, Ocak 2007-Mart 2023 tarihleri arasında ÇZ temelli öğretimin etkisi üzerine yazılmış araştırma makalelerini içerik, amaç, katılımcı, materyal, desen, sonuç ve yayın yılları açısından sistematik ve eleştirel bir şekilde analiz etmektir.

Materyal ve Yöntem: Bu sistematik inceleme çalışmasında PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) kullanılmış ve belirlenen uygunluk kriterleri aracılığıyla 68 araştırma makalesi analize dâhil edilmiştir. Çoklu zekâ temelli öğretimin etkileri üzerine yapılan 68 araştırmayı düzenlemek ve analiz etmek için betimsel analiz yöntemi kullanılmıştır.

Bulgular: Bulgular, analiz edilen çalışmalarda, çoklu zekâ temelli öğretimin (1) başarı, (2) tutumlar, (3) kalıcılık ve (4) öğretmen ve öğrencilerin çoklu zekâ temelli öğretimin etkililiğine ilişkin görüşleri üzerindeki etkisi olmak üzere dört ana temanın baskın olduğunu ortaya koymuştur. Çoklu zekâ temelli öğretimin başarıya etkisinin en çok çalışılan tema olması ve deneysel desenli çalışmaların nitel olanlara kıyasla baskın olması nedeniyle, analiz edilen çaışmalarda, sınav odaklı anlayışın ve pozitivist araştırma geleneğinin baskınlığı oldukça belirgindir.

Önemli Vurgular: Bulgular, konuya yönelik artan ve azalan ilgiyi açıkça ortaya koymuştur. Çoklu zekâ kuramının 2004 yılında ulusal eğitim programına dâhil edilmesinin ardından çoklu zekâ kuramına olan ilgi ve dikkat artmış, ancak 2006 yılından sonra, bu ilgi kısa sürede giderek azalmıştır. Öte yandan, gelecekteki araştırmalarda dikkate alınması gereken bazı eksiklikler de bulunmaktadır. Örneğin, bu derleme çalışması, ÇZ temelli öğretim üzerine yapılan çalışmalarda teorinin doğası ve metodolojik seçimler arasında tutarsızlıklar olduğunu ortaya koymuştur.

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Citation/Alıntı: Karakuş Özdemirci, Ö. (2025). A Systematic Review of Research Articles on the Effects of Multiple Intelligences-Based Instruction in Türkiye, *Kastamonu Education Journal, 33*(2), 304-321. doi: 10.24106/kefdergi.1683457

INTRODUCTION

Intelligence has long been a contentious construct, yet early twentieth-century discourse adopted a scientific lens. Pioneers such as Spearman, Galton, Binet-Simon, Stern, Terman, or Weschler contributed to the establishment of the "general intelligence" framework, while some others debated its "multiplicate" nature (Şakir, 2013). In 1983, Howard Gardner's seminal work, 'Frames of Mind,' introduced the 'theory of multiple intelligences' (MI theory), positing intelligence as multidimensional and modular, thereby challenging the prevailing notion of a singular intelligence (Davis, Christodoulou, Seider & Gardner, 2012).

Gardner's inquiry into the workings of the human mind unexpectedly resonated with educators (Campbell & Campbell, 1999). By 2011, scholarship on MI theory in educational contexts coalesced in "*Multiple Intelligences Around the World,*" edited by Chen, Moran, and Gardner, showcasing applications across diverse age groups and settings -including schools, museums, and after-school activities- demonstrating the theory's widespread impact (Davis, Christodoulou, Seider & Gardner, 2012). The rapid embrace of MI theory in education is attributable to its promise of recognizing the unique potential of each learner. Traditionally, educational systems prioritized linguistic and logical-mathematical intelligences, often leading to detrimental labelling. Conversely, Gardner's perspective affirms the distinct capacities inherent in all individuals (Davis, Christodoulou, Seider & Gardner, 2012; Gardner, 2013). MI theory expands the conceptualization of intelligence and asserts the developmental nature of cognitive abilities, allowing for greater personalization of educational experiences. As such, it offers more expansive avenues for student growth than general intelligence theories, emphasizing intelligence as a blend of heritable traits and skills fostered through diverse experiences (Davis, Christodoulou, Seider & Gardner, 2012).

There is another notable divergence between MI and general intelligence theories concerning their educational implications. Gardner eschewed the development of psychometric tools for assessing multiple intelligences, positing that "*intelligence is too important to be left to the intelligence testers*" (Gardner, 1999). He drew from research -including evolutionary biology, neuroscience, anthropology, psychometrics, and psychology- to delineate eight criteria for identifying a distinct intelligence: (1) the existence of savants, prodigies, and other exceptional individuals, (2) a distinctive neural representation, (3) a distinctive developmental history and a definable set of expert 'end-state' performances, (4) some basis in evolutionary biology, (5) support from psychometric findings, (6) support from experimental psychological tasks, (7) an identifiable core operation or set of operations, and (8) susceptibility to encoding in a symbol system (Davis, Christodoulou, Seider & Gardner, 2012; Arca, 2013). In this context, Gardner characterizes intelligence as a bio-psychological potential for problem-solving or producing culturally valued outputs. He articulates eight relatively autonomous intelligences -verbal-linguistic, mathematical-logical, visual-spatial, bodily-kinaesthetic, musical, interpersonal, intrapersonal, and naturalistic (Scapens & Fraser, 2007; Davis, Christodoulou, Seider & Gardner, 2012; Arca, 2013)- which can be cultivated through enrichment and instruction, and interact in intricate ways. Despite criticisms regarding the scientific validity of MI theory (Allix, 2000; Sternberg & Grigorenko, 2004; Waterhouse, 2006) and concerns about its comprehensibility (Klein, 1997) and educational applicability (Waterhouse, 2006), it has engendered a constructive discourse on the uniqueness of intelligence and diverse student learning profiles, fostering optimism about the potential of all learners. This paradigm has positively influenced the beliefs of educators regarding student intelligence, achievement, and instructional strategies, which may explain the sustained interest in MI-based educational research (Campbell & Campbell, 1999; Chen, Moran & Gardner, 2011).

Multiple Intelligences-based Instruction

Since Gardner introduced the MI theory, it has significantly impacted educational practices. Hopper and Hurry (2000) articulate three compelling rationales for adopting MI as an instructional framework: (1) enhancing students' awareness of their learning processes, (2) individualizing learning experiences, and (3) fostering active engagement in the learning process. Armstrong (2000) further asserts that MI theory significantly enriches pedagogy by urging educators to diversify their instructional techniques, tools, and strategies beyond the traditional reliance on linguistic and logical modalities.

Moran, Kornhaber, and Gardner (2006) delineate MI-based instruction's content, purpose, and position within the classroom context. They assert that the fundamental purpose of education, according to MI theory, is to cultivate intelligences that enable students to achieve goals aligned with their distinct intelligence profiles. Thus, accommodating student diversity by integrating various intelligence types into lessons through a broad spectrum of learning experiences and delivering student-centered instruction are central for MI-based instruction.

Kaya (2009) identifies three seminal pioneers in the realm of MI-based instruction: Lazear (1992) in "Teaching for Multiple Intelligences," Armstrong (1994) in "Multiple Intelligences in the Classroom," and Campbell, Campbell, and Dickinson (1996) in "Teaching and Learning through Multiple Intelligences." These works delineate MI-based pedagogical strategies and illustrate their application within educational settings, emphasizing requisite teacher characteristics and behaviours conducive to MI classrooms. MI theory underscores the heterogeneity in student learning profiles. Through MI-based instruction methods, educators can devise multiple entry points -varied activities and modalities corresponding to distinct intelligences- enabling a wider array of students to engage with content and demonstrate comprehension through their inherent strengths (Campbell & Campbell, 1999; Scapens & Fraser, 2007). Gardner likens these entry points to doors accessing the same room (as cited in Scapens & Fraser, 2007).

Nevertheless, the proliferation of MI theory since the 1990s has engendered misconceptions and detrimental practices. Gardner (1995; 2011) critiques certain educational applications of MI, arguing against the futile endeavour of teaching all concepts through

all intelligences and cautioning against the evaluative labelling that could arise from contextually insensitive assessments. Furthermore, he posits that MI should serve as an educational tool rather than an ultimate objective.

Superficial activities, such as integrating music into mathematics instruction, are deemed by Gardner to perpetuate myths surrounding MI rather than embodying its authentic principles. Still, Gardner posits that MI theory can enhance educational practices by facilitating the pluralization of subject matter and personalizing student learning experiences. He asserts that a robust educational foundation is established if this personalization is coupled with a commitment to achieving meaningful educational understandings for all children (Gardner, 1995; 2011).

These promises provide interest in MI theory, and the existing literature supports the claim that MI theory is associated with several positive outcomes on student achievement, student participation, students' attitudes, motivation, self-confidence, meta-cognition, critical thinking, conceptual skills or self-efficacy in schools (Campbell & Campbell, 1999; Goodnough, 2001; Scapens & Fraser, 2007). Additionally, research demonstrates the positive influence of MI theory on teachers' perception of intelligence, instruction, and student achievement (Campbell & Campbell, 1999). Moreover, the "Schools Using Multiple Intelligences Theory" (SUMIT) project, conducted across 41 schools in the U.S. from 1997 to 2000, evidenced MI's positive impacts on school discipline, parental engagement, and learning gains among diverse student populations (Saban, 2009).

Despite the positive outcomes associated with MI-based instruction, research analysis in both global and Turkish contexts reveals four predominant themes. Türkiye The first three represent the variables that are affected by MI-based instruction: (1) student achievement, (2) student attitudes, and (3) retention; and the fourth theme, (4) teachers' or students' views, mainly analyses the effectiveness of MI-based instruction through opinions. Some studies explore multiple themes, such as the interplay between MI and achievement, retention, and attitudes. A comprehensive examination of each theme will be undertaken in the subsequent results and discussion sections.

The Significance of MI-based Instruction in Türkiye

MI theory became integral to the Turkish education system post-reform in 2004 (Dönder, Batdı & Akpınar, 2015; Yurt & Polat, 2015), aligning with the constructivist paradigm that emphasizes individual differences following curriculum reconstruction (Yurt & Polat, 2015). Consequently, research on MI theory and MI-based instruction surged, particularly from 2005 to 2009, peaking in 2006; however, it declined after 2009 (Saban, 2009; Karabay, Işık, Günay-Bilaloğlu & Kuşdemir-Kayıran, 2011; Dönder, Batdı & Akpınar, 2015). The accompanying table (Table 1) illustrates the trajectory of theses addressing MI theory within educational contexts from 1998 to 2003, highlighting a rise in academic interest commencing around 2003, reaching a zenith in 2006, followed by a gradual decline thereafter.

Table 1. The Number of Master's and Doctoral Theses on MI Theory in the Field of Education

Year	Number of Master's theses	Number of Doctoral theses	Total
1998	1	-	1
1999	1	-	1
2000	2	-	2
2001	3	1	4
2002	5	-	5
2003	13	4	17
2004	19	-	19
2005	21	6	27
2006	40	2	42
2007	23	3	26
2008	18	3	21
2009	15	4	19
2010	15	2	17
2011	8	-	8
2012	8	2	10
2013	9	1	10
2014	2	2	4
2015	5	-	5
2016	8	-	8
2017	5	1	6
2018	5	-	5
2019	8	-	8
2020	5	1	6
2021	2	-	2
2022	7	-	7
Total	248	32	280

There are two Master theses (Kural, 2020; Gürsu, 2022) that have conducted meta-analysis on the effects of MI-based instruction in science education. Kural (2020) reviewed experimental studies -including theses and peer-reviewed articles- published between 2006 and 2019, culminating in examining 69 studies to assess the impact of MI-based instruction on student achievement and attitudes. Similarly, Gürsu (2022) synthesized findings from 98 Master's and doctoral theses written between 2000 and 2020 that investigated MI's influence on academic performance and attitudinal shifts in science education.

Besides these, several meta-analysis studies have targeted the effect of MI-based instruction on academic success, attitude, and retention. Yurt and Polat (2015) reviewed 66 theses and seven peer-reviewed articles that used experimental design and were published between 2000 and 2014. Baş (2016) covered 75 experimental theses published between 1998 and 2014, while Aydın's (2019) meta-analysis study involved 66 theses and 30 peer-reviewed articles published between 2001 and 2014. These meta-analysis studies targeted to analyse the effect of MI-based instruction on academic success. Unlike these, one meta-analysis study only focused on the effect of MI-based instruction on mathematics achievement (Kaplan, Duran & Baş, 2015). Finally, Batdı (2015) included 51 studies published between 2000 and 2014 to analyse the effect of MI-based instruction on achievement, attitude, and retention.

In addition, several review studies have explored MI theory within the educational context in Türkiye. Saban (2009) evaluated 79 theses and 18 articles published in Turkish from 1999 to 2007, while Karabay et al. (2011) examined 176 theses from 1998 to 2010. Dönder, Batdı, and Akpınar (2015) critically reviewed 116 theses conducted between 2001 and 2012. These comprehensive reviews offer a broader perspective on MI theory in education, whereas the present study concentrates explicitly on the effects of MI-based instruction.

Problem of the Study

This review critically analyses research studies addressing the effects of MI-based instruction within the context of Türkiye between January 2007 and March 2023. Since Saban (2009) extensively reviewed both theses and articles from 1999 to 2007, reiterating that analysis would be redundant. Consequently, studies post-2006 are examined to synthesize an overarching perspective from the late 1990s. Additionally, prior works by Karabay et al. (2011) and Dönder, Batdı, and Akpınar (2015) overlooked published articles, underscoring the necessity of including research from the past 16 years. This review aims to systematically and critically analyse peer-reviewed articles on the effects of MI-based instruction, authored in Turkish and English, within this timeframe. Such a review study is essential because it has become vital to scrutinize the corpus of research examining the pervasive implications of MI theory, which has rapidly ascended to prominence and profoundly influenced curriculum developments since 2004. It is imperative to recognize that, despite a decline in interest, MI-based instruction still significantly impacts researchers and educators. Therefore, conducting a study on MI-based instruction is essential for uncovering the extensive outcomes associated with its application in educational practices. This analysis aims to synthesize the findings of existing studies on the subject, thereby providing a foundational framework to inform future inquiries into this topic and related domains. Ultimately, the central research question addressed is:

What trends characterize research articles on the effect of MI-based instruction regarding content, purposes, participants, materials, designs, results, and publication years conducted in Türkiye from January 2007 to March 2023?

METHOD

This section includes information about the review protocol, resources, systematic review process, and data analysis.

The Review Protocol

This systematic review study employs the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) framework. PRISMA provides a set of items and a standard methodology for the meticulous reporting of systematic reviews, thereby enhancing the rigor of the review process (prisma-statement.org). By applying the PRISMA guideline checklist (Page et al., 2021), the eligibility criteria were determined, pertinent information sources were identified, a robust search strategy was formulated, and the selection process was delineated. Subsequently, the data collection methodology was explicitly recorded, culminating in thoroughly compiling all relevant data. A detailed exposition of the data sources and the systematic review process is elucidated in the following section.

Data Sources and Systematic Review Process

The educational literature was systematically explored within the electronic databases of EBSCOhost (including Academic Search Complete, Education Research Complete, Education Source, ERIC, Teacher Reference Center, and ULAKBIM) to identify peer-reviewed journal articles addressing the effects of MI-based instruction in Türkiye. Following the PRISMA guidelines by Page et al. (2021), a tripartite methodological approach -identification, screening, and inclusion- was employed to curate the final dataset. During the identification phase, the keywords to explore the literature in the selected databases were decided as "multiple intelligences theory," "multiple intelligences + classroom," "multiple intelligences + education," "instructional applications of multiple intelligences theory" and "multiple intelligences based instruction." These keywords were also rendered into Turkish to ensure access to articles published exclusively in that language.

A total of 143 Master's theses, 19 doctoral theses, and 2878 research articles (*n*=278) were catalogued, all of which pertained to MI theory in the field of education and were published between January 2007 and March 2023. Following an exhaustive examination of the graduate theses, 76 Master's theses and eight doctoral theses were identified that specifically addressed the effects of MI-based instruction. Given the existence of prior reviews (Dönder, Batdı & Akpınar, 2015; Karabay et al., 2011) and meta-analysis (Gürsu, 2022) studies, the search was refined to include only accessible full-text scientific articles published in academic journals within the aforementioned timeframe. In the subsequent screening phase, we established comprehensive inclusion and exclusion criteria. The table below encapsulates the eligibility criteria:

Table 2. The Eligibility Criteria

Criterion	Inclusion	Exclusion
Specific subject (the focus of the study)	The effect of MI-based instruction on achievement, attitude, and retention; and teachers' and students' views on the effect of MI-based instruction	Measuring MI types of children or students, curriculum or textbook analysis regarding MI theory, Scale development studies
Literature type	Scientific articles (could be produced from a thesis)	Graduate theses, Systematic review studies, meta-analysis studies
Conducted country	Türkiye	Countries except for Türkiye
Language	Turkish, English	Non-Turkish and Non-English
Published date	Between January 2007 and March 2023	Before 2007
Accessibility	Full-text accessible articles	Not accessible articles, conference abstracts

After setting the eligibility criteria, a comprehensive review of the potential scientific articles was conducted, excluding certain studies. Specifically, articles that were duplicate publications (n=22) or focused on measuring Multiple Intelligences (MI) among students, scale development, or analyses of curricula and textbooks were omitted (n=176).

Later, a secondary review process was employed for the 80 selected scientific articles, which was more detailed and consisted of a full-text reading process. As previously indicated, both international and national literature predominantly segregates into four salient themes concerning the ramifications of MI-based instruction: (1) student achievement, (2) student attitudes, (3) retention, and (4) teachers' and students' views. The primary objective of this review study was to elucidate the overarching patterns associated with MI-based instructional research within the national context. Nevertheless, 12 studies that explored the effect of MI-supported cooperative learning (Ilgar & Babacan, 2012; Işık & Tarım, 2009; Işık, Tarım & İflazoğlu, 2007; Kayıran & İflazoğlu, 2007; Yıldırım & Tarım, 2008), MI-supported lecturing model (Nacakcı, 2009), MI-supported project-based learning (Baş &Beyhan, 2010; Tabuk & Özdemir, 2010; 2011), MI-supported layered curriculum (Bilgili, Gömleksiz & Öner, 2020; Koç & Şahin, 2014), and MI-supported 5E learning cycle (Tüysüz & Geban, 2020) were excluded from the data to strengthen and support the intensiveness of discussion through four main themes.

Additionally, there were ten studies that, while capable of being classified into the four primary themes, also investigated the impact of MI-based instruction on facets such as self-efficacy (Epçaçan, 2013a), knowledge level (Baş, 2010a), conceptual learning (Baki, Gürbüz, Ünal & Atasoy, 2009; Gürbüz, Birgin & Çatlıoğlu, 2014), meta-cognition (Durmuş & Özdemir, 2013), reading comprehension skills (Epçaçan, 2013b), critical thinking (Kırıktaş & Ünal-Çoban, 2016), writing skill development (Elgün, Gündüz & Ünal, 2016), ecological awareness (Akkuzu, Güven & Uyulgan, 2021), and children's learning styles, interests and active participation (Gürkan, Dinçer & Çabuk, 2010). The pertinent segments of these studies were included in one of the four predetermined themes. Ultimately, 68 research articles were included in the present review study regarding the determined criteria. The final step (inclusion) covered all included scientific articles' reading and coding processes. A study flow diagram succinctly encapsulates the systematic review process employed:

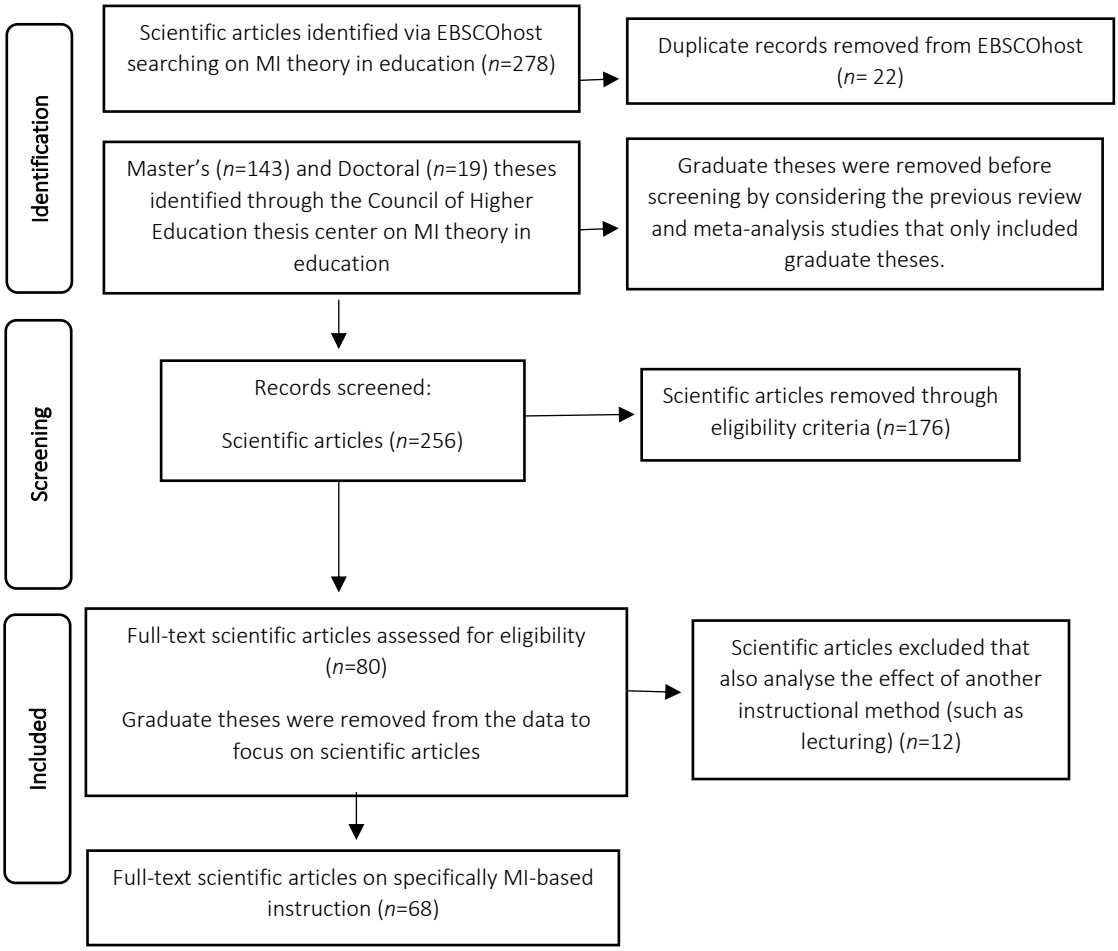

Figure 1. The flow diagram of the review (based on the PRISMA flow diagram by Page et al., 2021)

In short, scientific articles written within the context of Türkiye between January 2007 and March 2023 that are accessible and examine the effect of MI-based instructional practices constitute the primary data sources for this study. Furthermore, the reference lists of the found studies were examined to ensure that all relevant articles were contained in the data pool. Nonetheless, despite the meticulous steps undertaken during the literature searches to assemble a representative corpus about the effects of MI-based instruction, it is conceivable that some relevant studies may have inadvertently been omitted from the current review.

Data Analysis

A descriptive analysis was employed to systematically organize and evaluate the 68 research studies examining the effects of MI-based instruction. According to Yıldırım and Şimşek (2013), descriptive analysis seeks to transform data into an interpretable format. Consequently, the data was systematically arranged and structured regarding the research purpose by using NVivo 14 to yield descriptive insights. As previously noted, the identified and selected articles were categorized into four predetermined thematic areas based on prevailing international and national literature trends. Nevertheless, it is important to acknowledge that the content of certain studies may overlap with multiple themes; thus, pertinent sections were included and discussed within both relevant themes. The analysis was structured around these areas, with points categorized as codes under each theme. This approach aimed to evaluate the articles within the data pool descriptively. Frequency tables and percentages derived from descriptive statistics were utilized to facilitate interpretation. Given that this review focused on the content and context of the studies, it was assumed that the findings presented were valid and reliable.

FINDINGS

The distribution of the reviewed studies (*n*=68) regarding their themes, publication years, research designs, participants, and subject fields are shared in the following sub-sections.

Distribution of the Reviewed Studies Regarding Themes

Sixty-eight research articles were reviewed through the four predetermined themes - the effects of MI-based instruction on student achievement, (2) the effects of MI-based instruction on student attitudes, (3) the effects of MI-based instruction on retention, (4) teachers' and students' views on the effectiveness of MI-based instruction- to generate an understanding of research on the effects of MI-based instruction in Türkiye. As illustrated in Table 2, the findings revealed that most studies concentrated on the effectiveness of MI-based instruction in enhancing student achievement. Conversely, research on teachers' and students' perspectives received moderate attention. At the same time, studies examining the impact of MI-based instruction on attitudes and retention were notably fewer than the most extensively researched theme.

Table 3. Distribution of Studies Regarding Four Main Themes

Themes / Sub-categories	Publication	*f*
Student Achievement	Karakoç & Sezer (2007); Kaya et al. (2007); Köksal & Yel (2007); Temur (2007); Demirci & Yağcı (2008); Demirel et al., (2008); Öngören & Şahin (2008); Yılmaz (2008); Alaz (2009); Çırakoğlu & Saracaoğlu (2009); Sivrikaya & Kaya (2009); Baş (2010b); Çelen, Mirzeoğlu &Mirzeoğlu (2010); Oral & Doğan (2010); Can, Altun & Harmandar (2011); Kurt & Temelli (2011); Kurt, Gümüş & Ermurat (2011); Şengül & Altuntaş (2011); Uzunöz & Akbaş (2011); Erkaçan, Moğol & Ünsal (2012); Erkan & Üster (2012); Durmuş & Özdemir (2013); Güney, Aytan & Şengül (2014); Gürbüzoğlu-Yalmancı & Gözüm (2013); Kurt, Gümüş & Temelli (2013); Kaplan & Yılmaz (2015); Gülfırat Kıbrız (2016); Kılıç & Şahin (2016); Kırıktaş & Ünal-Çoban (2016); Gurcay & Ozturk-Ferah (2017); İnan & Erkuş (2017); Sağıroğlu (2017); Batdal-Karaduman & Cihan (2018); Akkuzu-Güven & Uyulgan (2021); Irmak & Çelik (2021)	35
Teachers' and Students' Views	Bozkurt & Yenilmez (2008); Demirel, Tuncel, Demirhan & Demir (2008); Gürçay & Eryılmaz (2008); Yılmaz (2008); Keser & Çakır (2009); Kutluca et al. (2009); Gürkan, Dinçer & Çabuk (2010); Özbaş (2010); Karatekin, Sönmez & Kuş (2010); Uşun (2010); Epçaçan (2013b); Gürbüz & Baki (2013); Ozan, Taşgın, Bay & Kaya (2013); Baş (2014); Elgün-Gündüz & Ünal (2016); İnan & Erkuş (2016); Çakır & Keser (2017); Çelik-Karacalı & Tezel (2017); Gökbulut & Dirik (2017); Kabapınar & Sargın (2018); Şener & Doğan (2021)	21
Student Attitudes	Kaya et al. (2007); Köksal & Yel (2007); Temiz & Kiraz, (2007); Alaz (2008); Demirel et al., (2008); Şengül & Öz (2008); Epçaçan (2013a); Sivrikaya & Kaya (2009); Baş (2010a); Baş (2010b); Çelen, Mirzeoğlu & Mirzeoğlu (2010); Şahin, Öngören & Çokadar (2010); Uzunöz (2010); Ayaydın & Özsoy (2011); Can, Altun & Harmandar (2011); Erarslan-Taşpınar & Kaya (2016); Kılıç & Şahin (2016); Gurcay & Ozturk-Ferah (2017); Irmak & Çelik (2021)	19
Retention	Köksal & Yel (2007); Temur (2007); Demirel et al., (2008); Hasenekoğlu & Gürbüzoğlu (2008); Baki, Gürbüz, Ünal & Atasoy (2009); Can, Altun & Harmandar (2011); Şengül & Altuntaş (2011); Uzunöz & Akbaş (2011); Erkaçan, Moğol & Ünsal (2012); Gürbüzoğlu-Yalmancı & Gözüm (2013); Akçin & Baktaş-Çetinkaya (2014); Gürbüz, Birgin & Çatlıoğlu (2014); Kaplan & Yılmaz (2015)	13

In Table 3, the studies that investigated more than one theme were included to show the tendency regarding four main themes. However, Table 4 displays the exact distribution of themes of the reviewed studies:

Table 4. Distribution of Studies Regarding Themes in Detail

Themes	Frequency (*f*)
Achievement	18
Attitude	9
Retention	4
Achievement + Attitude	7
Achievement + Retention	6
Achievement + Attitude + Retention	3
Teachers' and Students' View	8
Teachers' View	9
Students' View	3
Achievement + Students' View	1

The findings from the review -detailed in Table 3- indicate a noteworthy prevalence of research studies analysing the effect of MI-based instruction on academic achievement, outnumbering investigations focused on other themes. This trend may be attributed to Türkiye's exam-oriented educational system prioritizes national examinations and academic performance over students' interests, skills, or overall well-being (Öztekin-Bayır & Tekel, 2021). Furthermore, the perspectives of both teachers and students regarding the efficacy of MI-based instruction have been more extensively examined compared to the effects of MI on attitudes or knowledge retention. This observation aligns with previous reviews by Saban (2009) and Dönder, Batdı, and Akpınar (2015). The emphasis on teachers' perspectives is particularly pertinent in the context of the curriculum changes implemented in 2004. As numerous scholars have criticized (Bozkurt & Yenilmez, 2008; Gürçay & Eryılmaz, 2008; Kutluca et al., 2009; Özbaş, 2010; Karatekin, Sönmez & Kuş, 2010; Uşun, 2010; Gürbüz & Baki, 2013; Ozan, Taşgın, Bay & Kaya, 2013; Baş, 2014), the knowledge and

experience levels of teachers concerning MI-based instruction may pose significant challenges to the effectiveness of such pedagogical approaches. Consequently, the insights of educators are critical for formulating recommendations to enhance instructional efficacy.

Distribution of the Reviewed Studies Regarding Publication Years

Regarding publication years, the distribution of studies revealed no significant increase in the last 16 years in the studies about the effect of MI-based instruction, which is parallel with the number of theses written (Table 1). Table 5 shows the number of articles written between 2007 and 2023.

Table 5. Distribution of Studies Regarding Publication Years

Year	Frequency *(f)*
2007	5
2008	9
2009	8
2010	10
2011	6
2012	2
2013	6
2014	4
2015	1
2016	6
2017	6
2018	2
2019	-
2020	-
2021	3
2022	-
2023	-

Conversely, there exists a notable decline commencing in 2010, with a marked reduction in empirical investigations, particularly post-2017. These findings show that after the peak in 2006, the number of studies on MI theory in education gradually decreased, and there are only a few studies since 2018. In other words, the subject started to be investigated after the sudden implementation of MI theory in the national curriculum in 2004. Especially between 2005 and 2009, many studies were conducted on the MI theory in education (Dönder, Batdı & Akpınar, 2015). However, this trend has since exhibited a downward trajectory, potentially indicative of the literature reaching a state of saturation regarding the subject (Dönder, Batdı & Akpınar, 2015).

Moreover, the findings from the reviewed studies in the present study mainly highlighted that teachers must have adequate knowledge and experience. They need in-service training to apply MI-based activities in classrooms. Consequently, a consensus is evident among researchers that MI-based instruction ought to be incorporated into the curricula of teacher education programs (Bozkurt & Yenilmez, 2008; Gürçay & Eryılmaz, 2008; Kutluca et al., 2009; Özbaş, 2010; Karatekin, Sönmez & Kuş, 2010; Uşun, 2010; Gürbüz& Baki, 2013; Baş, 2014; Şener & Doğan, 2021).

Nonetheless, these recommendations have been largely overlooked, as neither in-service training nor dedicated undergraduate courses addressing MI theory have been established since the theory was designated as a principal framework during the curriculum revision in 2004. This oversight may contribute to a gradual distancing from the discourse surrounding the subject over time.

Distribution of the Reviewed Studies Regarding Research Designs

The reviewed studies are analysed in terms of the research design they conducted. As seen in Table 6, the experimental and quasi-experimental designs have been used in most studies that analysed the effect of MI-based instruction.

Table 6. Distribution of Studies Regarding Research Design

Design	Frequency (*f*)	Percentage (%)
Experimental and quasi-experimental research	46	67.6
Survey design	9	13.2
Qualitative research (not specified)	5	7.4
Qualitative case study	5	7.4
Action research	2	2.9
Mixed methods research	1	1.5

The experimental studies primarily focused on comparing the effects of MI-based instruction with traditional instruction in terms of achievement, attitude, or retention. Control and experimental groups were established to conduct these studies. The MI-based methods were implemented over a limited period, typically four weeks, while traditional instructional methods were

used for the control groups. Following the instruction period, outcomes were assessed through achievement tests or attitude scales to evaluate the effectiveness of MI-based instruction compared to traditional methods. The table below (Table 6) outlines the durations of these applications:

Table 7. Duration of applications for experimental and quasi-experimental studies

Duration	Not specified	Week									
		1	2	3	4	5	6	7	9	10	12
Frequency (f)	8	2	3	3	13	5	4	2	1	3	2

The dominance of the positivist approach in the field of education in Türkiye may explain the preference for intensive experimental designs, tests, scales, or surveys over qualitative data collection methods (Dönder, Batdı & Akpınar, 2015). The choices made by educational researchers regarding research design or data collection may reflect their overall understanding or approach to the subject matter and the education system. For example, in the reviewed studies, multiple intelligences (MI) are considered significant in analysing their effects on achievement, retention, and attitudes toward the subject, all of which relate to educational achievement. Furthermore, the specifics of the instructional applications based on MI were not shared, and the majority of the experimental studies (n=29) did not discuss MI-based methods and techniques. As a result, the literature lacks quality information regarding the methods, techniques, or activities grounded in MI theory. A few experimental studies (n=18) contained some relevant information. However, three of these studies can be criticized for using questionable methods -such as playing music during lessons or employing practices that may lead to the labelling of students (Alaz, 2009; Erarslan, Taşpınar & Kaya, 2016; Güney, Aytan & Şengül, 2014).

Moreover, researchers predominantly opted to use tests to measure achievement or attitudes. Using tests or scales contradicts the essence of MI theory, as Kurt and Temelli (2011) have indicated. Gardner (2013) emphasized two key educational implications of MI theory: individuation (personalization) and pluralization. Pluralization refers to teaching the same subject in various ways. In many experimental and quasi-experimental studies, applications lasted from 1 to 12 weeks and involved several activities based on multiple intelligences, which aimed to ensure pluralization. However, personalization -which pertains to the individualization of teaching and assessment- was not adequately achieved, as standardized testing tools (scales, achievement tests) were primarily used. Only a few experimental studies (n=11) (Öngören & Şahin, 2008; Yılmaz, 2008; Epçaçan, 2013a, 2013b; Sivrikaya & Kaya, 2009; Çelen, Mirzeoğlu & Mirzeoğlu, 2010; Şahin, Öngören & Çokadar, 2010; Can, Altun & Harmandar, 2011; Erkaçan, Moğol & Ünsal, 2012; Elgün-Gündüz & Ünal, 2016) employed semi-structured interview forms or observation forms in addition to the scales and achievement tests. Notably, only one study lasted an entire semester (one of the most prolonged application durations), using only midterm and final scores without additional scales or tests (Erkan & Üster, 2012).

In addition to experimental and survey designs, the number of qualitative studies (n=12) was comparatively low. Action research (n=2) can potentially expand knowledge and practice in this field, as enhancing teachers' instructional and assessment repertoire is crucial for the two important concepts of MI theory in education: pluralization and individualization (Gardner, 2013).

Distribution of the Reviewed Studies Regarding Participants

The grade level of participants is a significant concern in the literature on MI-based instruction. As highlighted by Hodge (2005) and Scapens and Fraser (2007), there is a need for more research examining the impact of MI-based instruction on achievement, attitudes, retention, self-efficacy, and self-confidence among secondary school students (grades 6 to 12). It is suggested that the perception of MI-based activities being more suitable for younger children contributes to this oversight. However, as illustrated in Table 8, a substantial portion of research has focused on students in grades 6 to 8 (39.7%). In comparison, a notable number of studies investigated high school students (19.1%), and there was also attention given to undergraduate students (8.8%).

These findings align with Saban's review study (2009), which indicated that 35.1% of studies were conducted with middle school students, whereas 17.5% were focused on high school students. Consequently, there appears to be a discrepancy between national and international literature concerning the participants' grade level or age. Additionally, since MI theory was established as part of the 2004 national curriculum, understanding teachers' perspectives (f=8) is crucial for assessing the theory's effectiveness and application.

Table 8. The Distribution of Studies Regarding Participants' Class Levels

Participants	Frequency
Pre-school students	1
Primary education students (1 to 5th grade)*	13
Middle school students (6th to 8th grade)	27
High school students (9th to 11th grade)	13
Teachers	8
Undergraduate	6

*Only one study involving 5th-grade students was conducted and published before 2012 when primary education lasted five years.

Distribution of the Reviewed Studies Regarding Subject Fields

Table 9 below shows the variety of fields studied through MI-based instruction:

Table 9. The Distribution of Studies Regarding Subject Fields

General subject field	Subject	Frequency (f)	Total Frequency (*f*)
Science	Science education (5th to 8th grade)	10	18
	Biology education (9th to 11th grade)	5	
	Physics education (9th grade)	3	
Math	-	-	13
Social sciences	Geography (6th to 9th grade)	5	11
	Life sciences (1st to 3rd grade)	4	
	Social studies (4th to 6th grade)	3	
Language education	Turkish literature	4	8
	English as a second language	4	
Elementary education	-	-	5
Art education	-	-	3
Physical education	-	-	2
Environmental education	-	-	2
Traffic education	-	-	2
Pre-school education	-	-	1
Religious culture and ethics	-	-	1
Architectural design	-	-	1

MI theory has been applied across various subjects, from environmental education to the arts. However, most studies have focused on math and science (f=31; 45.5%), which aligns with Saban's (2009) review findings. This emphasis on math and science may pose a problem concerning the nature of MI theory. Gardner argues that while logical-mathematical and verbal abilities are important, each individual possesses unique interests, abilities, strengths, and weaknesses. For instance, teaching math through music or physical activities supports this claim. Nevertheless, the predominance of studies aimed at enhancing student achievement or attitudes toward science and math raises questions. Why has less focus been on improving learning in music, art, or social sciences? Statistics reveal that most research on MI theory has concentrated on math and science, reflecting the curriculum's emphasis on these subjects and the standardized tests in Türkiye. However, this trend does not align with the foundational principles of MI theory.

DISCUSSION

The primary motivation behind this study was to critically analyse research on MI-based instruction in the educational context of Türkiye. This review aims to contribute to the national literature by comparing and contrasting national findings with international studies. Based on a selection of 68 research articles published between January 2007 and March 2023, the current review is based on four predetermined key themes consonant with international literature: the effect of MI-based instruction on (1) student achievement, (2) student attitudes, (3) retention of knowledge, and (4) the perspectives of teachers and students on the effectiveness of MI-based instruction. Each of these themes is discussed concerning its international context.

The Effect of MI-Based Instruction on Student Achievement

The concept of student achievement has emerged as a pivotal focus within educational research, and it is fundamentally understood as the extent of academic content mastery within a specified timeframe. Regardless of the frameworks employed - Multiple Intelligences (MI) theory, individual differences, varying interests, or distinct skill sets- the discourse invariably converges on "achievement."

A vast body of literature proved the effectiveness of MI-based instruction in enhancing student achievement (Duval & Mark, 1994; Hoerr, 1996; Campbell & Campbell, 1999; Goodnough, 2001; Kornhaber, 2004). The Schools Using Multiple Intelligence Theory (SUMIT), initiated by Project Zero investigators, provides the most compelling evidence supporting MI-based applications and their impact on student academic outcomes. Throughout three and a half years, SUMIT researchers amassed data from 41 diverse schools across 18 states that integrated MI theory into their curricula. The results were categorized into four distinct outcomes, with one specifically addressing academic achievement; remarkably, nearly 80% of participating schools reported enhancements in students' standardized test scores (as cited in Johnson, 2007).

The outcomes of the reviewed studies (n=68), which employed experimental designs to assess changes in student achievement, align consistently with findings from the broader international literature. However, the way they reached the data is quite different. For instance, Campbell and Campbell (1999) and Kornhaber, Fierros, and Veenema (2004) in the SUMIT project reached the data through observations and interviews in a natural setting of schools by observing students' improvement

throughout the project; they used the standardized test results of students which were a part of the standard teaching-learning process, as schools already applied the MI theory.

Conversely, researchers in Türkiye implemented additional experiments and activities within a constrained timeframe, predominantly spanning four weeks. This approach introduces potential limitations concerning the research design, as it diverges from the natural sequence of curricular implementation; instead, supplementary activities are utilized to evaluate the effectiveness of MI-based instruction in a restricted period. The duration of applications is a crucial factor in assessing the reliability and validity of findings, as highlighted by Saban (2009); notably, eight of the reviewed articles (17.4%) did not specify the duration of applications, and approximately 35.6% of the experimental studies were conducted over less than five weeks. Moreover, many reviewed studies prepared additional achievement tests to assess students' academic performance, which raises methodological concerns, as MI theory fundamentally challenges quantitative representations of intelligence. Kurt and Temelli (2011) acknowledged this inconsistency, advocating for using qualitative measurement techniques to derive data concerning students' academic achievement despite their research employing achievement tests.

In summary, it is evident that the conceptualization of "achievement" was problematic across the reviewed studies; framing the inquiry as "the effect of MI-based instruction on learning" may be more consistent with MI theory's theoretical foundations and assertions. Nonetheless, MI theory itself and its associated claims have the potential to yield positive outcomes, particularly for altering teacher perceptions. Echoing the Pygmalion effect, Gardner's framework suggests that every individual possesses the potential for success (Campbell & Campbell, 1999). When educators believe in each student's unique strengths, it can positively transform students' self-perceptions, consequently facilitating their cognitive, emotional, and social development (Akey, 2006). Gardner's work equips educators with a multifaceted model of intelligence, empowering them to nurture students' growth across diverse dimensions by fostering belief in their intrinsic potential (Campbell & Campbell, 1999).

The Effect of MI-Based Instruction on Student Attitudes

In psychological constructs, attitude is defined as an individual's evaluative response -encompassing behaviour, emotion, or cognition- toward an object, situation, or event (Atik, 2010). Within the framework of this review, the term "attitude" pertains explicitly to students' dispositions toward various academic subjects, including Mathematics, Biology, Music, and Art. The reviewed literature demonstrates a consistent methodology wherein researchers employed attitude scales to assess students' perceptions of these subjects. A positive attitude has been shown to correlate significantly with enhanced learning outcomes and academic achievement. Multiple Intelligences (MI) theory posits that recognizing individual differences in abilities, intelligences, interests, strengths, and weaknesses can lead to more effective educational practices. Instructional approaches encompassing all types of intelligences are likely to engender favourable attitudes towards the relevant subjects.

Empirical evidence indicates that MI-based instruction promotes a positive disposition among students toward the subject matter and cultivates essential skills such as motivation, participation, and engagement. The SUMIT project notably illustrated that integrating MI principles resulted in increased student motivation and participation and improved engagement levels. Furthermore, research conducted by Kornhaber, Fierros, and Veenema (2004) found a noteworthy reduction in disciplinary issues, positing that "student discipline is directly linked to student engagement." When students are actively engaged in their academic and social learning experiences, they are less likely to encounter disciplinary challenges (Johnson, 2007).

The findings from the reviewed studies reflect a consistent trend: nearly all studies utilized attitude scales to evaluate students' attitudes toward their subjects and collectively highlighted the positive impact of MI on motivation, interest, and participation. However, these additional insights were not solely derived from attitudes scales in experimental designs; several studies also incorporated qualitative methods such as interviews and observations (Temur, 2007; Öngören & Şahin, 2008; Şengül & Öz, 2008; Yılmaz, 2008; Sivrikaya & Kaya, 2009; Çelen, Mirzeoğlu & Mirzeoğlu, 2010; Epçaçan, 2013b; Elgün, Gündüz & Ünal, 2016; İnan & Erkuş, 2017). In these qualitative studies utilizing various data collection tools (Temiz & Kiraz, 2007; Demirel et al., 2008; Gürçay & Eryılmaz, 2008; Kutluca et al., 2009; Gürkan et al., 2010; Kılıç & Şahin, 2016; Kabapınar & Sargın, 2018; Şener & Doğan, 2021), similar conclusions were drawn. However, quantitative results from three distinct studies did not indicate a significant shift in students' attitudes toward the subjects (Köksal & Yel, 2007; Ayaydın & Özsoy, 2011; Kurt & Temelli, 2011). This suggests that a four-week timeframe may not effectuate meaningful changes in emotions, thoughts, behaviours, or attitudes. While the majority of studies indicate a positive transformation in students' attitudes toward their academic subjects, there remains a pressing need for qualitative research designs to thoroughly examine the application of MI theory and its resultant impacts within educational settings. The findings underscore that interviews and observations can yield a more nuanced understanding than traditional scales alone. Consequently, it may be prudent to shift the focus from a narrow examination of "attitude towards subject matter" to a broader investigation of "attitude towards school or the learning process." This shift could elucidate the intricate relationships among motivation, participation, positive attitudes, and engagement in educational contexts.

The Effect of MI-Based Instruction on Retention

Retaining learned material has long been a significant concern in education, commonly referred to as "retention" in academic studies. Recently, with the growing emphasis on brain research and cognitive psychology in the educational field, teachers are increasingly questioning how learning and memory function. MI theory offers a non-traditional perspective on this issue. MI theory claims that memory can be approached in various ways. Consequently, it allows teachers to become more actively involved in

making their lessons cater to the myriad paths of student learning and remembering (Anderson, 1998). The central question for research exploring the impact of MI-based instruction is whether it leads to lasting learning outcomes.

It can be asserted that the "retention" studies within the context of MI theory are linked to the potential connection between active learning and long-term knowledge retention. Research indicates that students' active engagement in learning enhances their ability to learn and remember (Chi, 2009). Given that MI-based instructional methods necessitate active participation and that MI-based classrooms prioritize student engagement, applying MI theory may enhance the likelihood of long-term knowledge retention.

The studies reviewed assessed retention through tests administered two weeks to a month after the intervention. Researchers predominantly employed achievement tests as retention measures to evaluate the durability of the knowledge imparted. Results of reviewed studies confirmed that MI-based instruction increases the permanence of knowledge (Köksal & Yel, 2007; Temur, 2007; Hasenekoğlu & Gürbüzoğlu, 2008; Can, Altun & Harmandar, 2011; Şengül & Altuntaş, 2011; Uzunöz & Akbaş, 2011; Erkaçan, Moğol & Ünsal, 2012; Gürbüzoğlu-Yalmancı & Gözüm, 2013; Akçin & Çetinkaya, 2014). However, it can be claimed that regarding the scope of the reviewed studies, retention as a construct in the instructional context or its relationship with MI theory was not discussed in detail or associated together.

Teachers' and Students' Views on the Effectiveness of MI-Based Instruction

The findings of this theme are crucial for analysing the potential of MI-based instruction within the context of education in Türkiye. The findings reveal that both teachers and students hold positive views on instruction based on MI theory. They agree that MI-based instructional methods enhance participation, motivation, self-confidence, and achievement. However, teachers interviewed in the reviewed studies predominantly emphasized the need for more knowledge, experience, and practice to implement MI-based instructional methods and create appropriate learning environments effectively. Additionally, the adequacy of classroom conditions -such as available materials and opportunities- emerges as another critical factor for successful practice. For instance, teachers frequently highlighted challenges such as large class sizes, a heavy curriculum load, and insufficient learning environment conditions, which are significant barriers to integrating additional MI-based activities. Consequently, the findings indicate that while MI theory is present in the national curriculum and teachers and students have a favorable view of MI-based instruction, achieving its practical application necessitates appropriate teacher training and classroom conditions.

Discussing ways to enhance these conditions is crucial, especially given that students generally express positive views about MI-based applications. Thus, the data from studies prioritizing teachers' opinions can serve as a valuable starting point for a more practical discussion.

In this context, seeking teachers' insights and consulting them about their experiences can establish a foundation for understanding the obstacles and conditions necessary for the effectiveness of MI-based instruction. Conducting experiments demonstrating the efficacy of MI-based instruction is only meaningful and efficient if teachers are knowledgeable and well-informed.

Furthermore, the qualitative studies reviewed provided more valuable insights than the experimental studies. The quantitative studies tended to employ similar designs and procedures across various subject areas, failing to elaborate on the techniques or methods used, and they inadequately defined MI-based instruction. Although nearly all of them recommended in-service training for teachers, the studies encompassed in the previous three themes primarily concentrated on the impact of MI-based instruction on student achievement, attitudes, and retention. In contrast, incorporating teachers' perspectives shifts the focus from these outcomes to the essential requirements for creating a learning environment conducive to improving those variables.

Discussing ways to enhance these conditions is crucial, especially given that students generally express positive views about MI-based applications. Thus, the data from studies prioritizing teachers' and/or students' opinions can be a valuable starting point for a more practical discussion.

In Table 10, teachers' and students' general views about the effectiveness of MI-based instruction are gathered to see all results clearly:

Table 10. Summary of Teachers' and Students' Views about the Effectiveness of MI-based Instruction

Teachers' views		Students' views	
Positive	Negative	Positive	Negative
-Prevents learning environments from being monotonous -Students experiencing success thanks to activities addressing different intelligence domains -Increased student self-efficacy, motivation, participation, and engagement -Provide meaningful learning	-No adequate knowledge about the theory and its application -Need in-service training -Inadequate conditions (materials, class size, classroom opportunities, time, and others) to apply such practices -Noisy environment, as students all together participate in the process, and this sometimes bothers -Course hours are not enough -Curriculum is quite intense and hinders the implementation of MI-based activities	-Enjoy learning through MI-based activities -Become motivated to learn -Communication skills improved -Started to believe in themselves -Increased participation -Could understand better through MI-based activities -More eager to study -Could explore and investigate individually -Feel more responsible for learning	-Noisy environment, as they all together participate in the process, and this bothers

CONCLUSION AND RECOMMENDATIONS

This review aims to analyse studies conducted in Türkiye from January 2007 to March 2023 regarding the effectiveness of instruction based on Multiple Intelligences (MI). The findings indicate a notable fluctuation in attention towards MI theory since its integration into the national curriculum in 2004. Initially, there was an increase in interest and engagement with MI theory; however, this interest began to decline significantly after 2006, suggesting that the theory had become a fleeting "trend." Numerous studies were conducted during this period, predominantly featuring similar research designs, but the overall interest in the topic has waned over time.

Moreover, several deficiencies must be addressed to enhance future research on MI-based instruction. To begin with, the content and structure of MI-based instruction processes should be more thoroughly elucidated and debated in future studies, as this may impede a clear understanding of the subject. Additionally, many studies lack a critical perspective on the inadequacies present in curricula or textbooks. It is also worth noting Gardner's (2013) critique that standardized assessment tools and quantitative evaluation methods do not align well with the essence of MI theory. Consequently, the design of experimental studies and the duration allocated for implementation and evaluation should be more congruent with the nature of the theory. There is a pressing need for more detailed, structured, and long-term studies to yield valid quantitative data. Ultimately, findings manifested that qualitative studies have produced more insightful interpretive data; thus, this perspective should gain greater prominence in future research.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest concerning the research, authorship, and publication of this article.

Funding

The author received no financial support for the research, authorship, and publication of this article.

Statements of Publication Ethics

I hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Ethics Committee Approval Information

This is a systematic review study; the data was from articles on MI-based instruction. Therefore, no application was made to any Ethics Committee.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 322-343
doi: 10.24106/kefdergi.1683465

|Research Article / Araştırma Makalesi|

A Holistic Understanding of Teacher Attitudes Towards Curriculum Change: Bronfenbrenner's Ecological Theory Perspective

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Keywords

1. Curriculum change
2. Ecological theory
3. Teacher self-efficacy
4. Teaching beliefs
5. Readiness for change

Anahtar Kelimeler

1. Program değişikliği
2. Ekolojik sistemler kuramı
3. Öğretmen özyeterliği
4. Öğretim inançları
5. Değişime hazır olma

Received/Başvuru Tarihi
23.02.2024

Accepted / Kabul Tarihi
14.04.2025

Abstract

Purpose: This study aimed to explore the underlying factors behind teachers' self-efficacy for teaching, beliefs about teaching, and their readiness for change in understanding their attitudes towards the constructivist curriculum change in Türkiye through the lens of Bronfenbrenner's ecological theory of education.

Design/Methodology/Approach: The study employed a phenomenological approach to uncover teachers' lived experiences concerning the factors influencing their attitudes towards the 2005 curriculum change in the Turkish education system. Twenty-one teachers from elementary, middle, and high schools were selected through maximum variation sampling. The data were collected through semi-structured, in-depth interviews, and analyzed using content analysis.

Findings: Concerning Bronfenbrenner's ecological framework, the findings resulted in the following themes: a) Teacher-related factors: Teacher characteristics, including their educational background, teaching experience, professional knowledge, skills, motivation, and emotional readiness. b) Micro-system and meso-system-related factors: K-12 school curricula, the involvement of students and parents, the physical and technological infrastructure of schools, the influence of school principals and colleagues in creating a supportive learning environment towards implementing the constructivist curriculum. c) Exo-system-related factors: Socio-cultural environment and mass media. d) Macro-system-related factors: The structural and operational challenges within the education system, the design and quality of professional development activities, the financial status of teachers and the inadequacy of the pre-service teacher education programs and practices, suggesting a pathway for enhancing overall teacher preparedness and support.

Highlights: The study provides the key stakeholders, especially education policymakers, curriculum development experts, school principals, and teacher educators, with essential insights for developing an understanding of the ecology of curriculum change and adopting a non-linear, holistic, and comprehensive view of curriculum change implementation. More specifically, the in-depth exploration of the factors influencing teachers' self-efficacy, general beliefs about teaching, and readiness for change call for those stakeholders to work collaboratively and develop effective strategies to support teachers, who are the curriculum makers and the agents of change, for a successful and sustainable curriculum change.

Öz

Çalışmanın amacı: Bu çalışma, Bronfenbrenner'ın ekolojik sistemler kuramı ışığında Türkiye'de öğretmenlerin yapılandırmacı program değişikliğine yönelik tutumlarını anlamak için öğretime yönelik özyeterliklerinin, öğretime ilişkin inançlarının ve değişime hazır olmalarının altında yatan faktörleri araştırmaktadır.

Materyal ve Yöntem: Bu çalışmada, öğretmenlerin 2005 yılında yürürlüğe giren ve hâlen Türk eğitim sistemini etkilemekte olan program değişikliğine yönelik tutumlarını etkileyen faktörlere ilişkin deneyimlerini ortaya çıkarmak amacıyla fenomenolojik bir yaklaşım kullanılmıştır. Çalışmaya ilkokul, ortaokul ve liselerden maksimum çeşitlilik örneklemesi yoluyla seçilen 21 öğretmen katılmıştır. Yarı yapılandırılmış derinlik odaklı görüşmeler yoluyla toplanan veriler içerik analizi yöntemi ile analiz edilmiştir.

Bulgular: Araştırmadan elde edilen bulgular, Bronfenbrenner'ın ekolojik sistemler kuramı çerçevesinde aşağıdaki temalar etrafında ortaya koyulmaktadır: a) Öğretmenle ilgili faktörler: öğretmen özellikleri, eğitim durumu, öğretim deneyimi, mesleki bilgi, beceri, motivasyon ve duygusal hazır olma; b) Mikro sistem ve mezo sistemle ilgili faktörler: K-12 programı, öğrencilerin ve velilerin katılımı, okulların fiziksel ve teknolojik altyapısı, okul müdürlerinin ve meslektaşlarının yapılandırmacı programın uygulanmasına yönelik destekleyici öğrenme ortamı yaratmaları; c) *Ekzo sistemle ilgili faktörler:* Okul çevresi ve kitle iletişim araçları. *d)* Makro sistemle ilgili faktörler: Eğitim sisteminin yapısı ve işleyiş sorunları, mesleki gelişim faaliyetlerinin tasarımı ve niteliği, öğretmenlerin finansal durumu ve hizmet öncesi öğretmen eğitimi programlarının ve uygulamalarının yetersizliği.

Önemli Vurgular: Bu çalışma, özellikle eğitim politikacıları, program geliştirme uzmanları, okul müdürleri ve öğretmen eğitimcileri başta olmak üzere çeşitli kilit paydaşlara, program değişimine ilişkin ekolojik bir bakış açısı ve değişimin uygulanmasına yönelik doğrusal olmayan, bütüncül ve kapsamlı bir anlayış sunmaktadır. Bu çerçevede, öğretmenlerin özyeterliklerini, öğretimle ilgili genel inançlarını ve değişime hazır olmalarını etkileyen faktörlerin derinlemesine araştırılmasından elde edilen bulgular, başarılı ve sürdürülebilir bir program değişikliği için kilit paydaşların iş birliği içinde çalışmalarını ve program yapıcıları ve değişimin aracıları olan öğretmenleri destekleyecek etkili stratejiler geliştirmelerini vurgulamaktadır.

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Citation/Alıntı: Akin-Sabuncu, S., & Calik, B. (2025). A Holistic Understanding of Teacher Attitudes towards Curriculum Change: Bronfenbrenner's Ecological Theory Perspective, *Kastamonu Education Journal, 33*(2), 322-343. doi: 10.24106/kefdergi.1683465

INTRODUCTION

Curriculum change has traditionally been seen as an important tool for educational reform, which typically entails the development of national curriculum plans for specific subject areas and the determination of certain objectives, activities, and evaluation for teaching and learning experiences. Especially over the last few decades, due to the increasing demands for the globalization of education standards to improve educational outcomes and raise a nation's human capital and economic competitiveness in the global arena, the reform of the school curriculum has been one of the key instruments of educational change for policymakers in many countries, including Türkiye. Underpinned by a process of constant reform (Levin, 2010), this international trend has, indeed, been characterized as an "epidemic" (Levin, 1998) of change. However, it is criticized that such a trend leads to a focus on performativity in the search for improved outcomes and therefore, reflects an important issue as education outcomes (e.g., the results of international tests such as PISA, TIMSS) are increasingly used as an indicator of the success of education systems across different subject areas.

Fullan (2013) describes that "educational change is technically simple and socially complex" (p. 111). This suggests that no matter if the change is externally imposed or voluntarily initiated; explicitly described in detail or developed gradually throughout implementation; designed to be flexible for modifications according to the varying needs or used uniformly regardless of different situations, there is a system of variables that interact to determine the success or failure of the change implementation. Those variables include the characteristics of change (e.g., complexity, practicality), local characteristics (teachers, principals, community, district), and external factors (e.g., government). Thus, while the simplicity of the technical aspect is no doubt, anyone involved in a change effort will encounter that implementing change is not an easy task, which requires "change in practice" (Fullan, 2016, p. 28).

Accordingly, for a successful change implementation, Fullan (1993) advises that in addition to teachers' change agentry at the individual level, institutional change at the school and system levels is also imperative, implying that successful change requires strategies both at the government or local authority level and at the teacher or school level. In the context of curriculum change, while this stresses the key role of several stakeholders in the process of change, teachers are still at the center of curriculum change as they are the main actors who will implement the change at the class level that is closest to instruction and learning (Rahimi & Alavi, 2017). Thus, teachers' attitudes towards implementing new and mandatory policies and practices are highly crucial for the success of the implementation, effectiveness, and continuation of change. Otherwise, if their attitudes and beliefs are neglected, teachers might show resistance to the intended change, and the success of change would be limited. In fact, efforts to change and improve education in general, and school curriculum specifically, often fail because those involved neither acknowledge nor understand the chief role that teachers play in the change process. Yet, change will always fail until we find some ways in which teachers engage in developing and applying new knowledge, skills, and understandings, while all real change involves, to some extent, loss, struggle, and uncertainty (Fullan, 2016).

Although the central role of teachers in successfully enacting such change has been long highlighted, teachers, in reality, usually feel a tension between a focus on educational outcomes vs. their educational values as well as the aims and purposes of the educational system (Biesta, 2015; Harris & Graham, 2019). Moreover, a tension has emerged between the prescriptive, centrally driven, and imposed curriculum reform which sees teachers as deliverers of the curriculum, and the view that empowers teachers to exercise agency, act as agents of change, and interpret the general guidelines into a curriculum (Carse, 2015; Priestley, 2011). Consequently, this has highlighted the question of what role teachers should play in curriculum change as there has been a growing counterview that teachers do not only deliver a prescribed curriculum, but indeed "they are the ones who give life and meaning to the curriculum" (Harris & Graham, 2019, p. 44) as curriculum makers.

To what extent teachers are encouraged and supported to implement the intended curriculum change also varies across education systems. The context of curriculum change we look at in this study is the constructivist K-12 curriculum introduced to Türkiye in 2005 after the termination of a long-established tradition rooted in behaviorism (Akinoglu, 2008; Bulut, 2007). The new curriculum has demanded a shift in teachers' instructional practices, moving away from teacher-centered towards more student-centered approaches. The process of curriculum changes in Türkiye, however, is usually bureaucratic, authoritative, and driven by policy mandates, rules, and regulations, consisting of several hierarchical levels, which generally takes a top-down approach with the Ministry of National Education (MoNE) at the top hierarchical level and teachers at the bottom. Thus, the introduction of the prescriptive, centrally driven constructivist national curriculum in Türkiye continued to position teachers as recipients and deliverers of the curriculum (Nohl & Somel, 2016). Once the curriculum was published and disseminated, teachers were required to implement the new curriculum. Initially, they were given the curriculum to make sense of it on their own or provided with limited or unsatisfactory in-service training before implementing the new curriculum (Yildirim & Kasapoglu, 2015). Yet, even though an effective curriculum change is highly dependent on teachers' knowledge, skills, beliefs, and attitudes, such change is also significantly influenced by factors external to teachers, such as professional development, physical resources, and instructional support (Clasquin-Johnson, 2016). Thus, in thinking about the success and effectiveness of curriculum change, it is not only necessary to understand teachers' attitudes towards the given curriculum change, but it is also of chief importance to explore the factors influencing teachers' attitudes when attempting to initiate and implement curriculum change.

In this study, we build on the findings of our previous work (Akin-Sabuncu & Calik, 2023) which mainly showed that teachers' attitudes towards curriculum change, specifically the constructivist curriculum change in the Turkish context, are significantly predicted by teachers' beliefs about teaching, self-efficacy beliefs for teaching, and readiness for change. Drawing on this work, the purpose of the present study is to further explore the factors underlying teachers' perceptions of their self-efficacy beliefs for teaching, teaching beliefs, and readiness for change, particularly in understanding how they influence teachers' attitudes towards the constructivist curriculum change. Grounded in Bronfenbrenner's ecological systems theory, this study examines these factors within the interconnected layers of the educational environment—ranging from individual teacher characteristics to broader systemic influences—to provide a comprehensive understanding of how various ecological levels shape teachers' attitudes and responses to curriculum reform. This is important because when the underlying factors are investigated, they might be manipulated, changed, or developed to better support teachers and improve the success of curriculum change. In line with this purpose, our inquiry was guided by the following research question: "How do teachers articulate what influences their self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change in relationship to their attitudes towards the implementation of a constructivist curriculum change?

Context of the Study

Under the given political and economic landscape during the harmonization period with the European Union (EU) membership, a top-down and government-led curriculum reform, known as a revolutionary move due to the transition from subject-centered to student-centered pedagogy (Kosar Altinyelken, 2011), has been put into practice in Türkiye since 2005-2006 academic year. Before the nationwide implementation, the new K-12 curricula were piloted by the Ministry of National Education (MoNE) in 120 schools at the primary level, selected from nine provinces in Türkiye in the 2004-2005 academic year. Following that pilot study, the new curricula were disseminated and implemented nationwide in the 2005-2006 academic year, starting with primary grades (Hazır Bıkmaz, 2006), followed by a gradual implementation across K-12 levels.

This curriculum reform paved the way for an inevitable change in the ultimate goals of education, the knowledge structure, the organization of the learning process and assessment practices, and the ascribed roles of teachers and students. More specifically, the new K-12 curricula focused on several core competencies, such as problem-solving, critical and creative thinking, decision-making, research and communication skills, entrepreneurship, and employment of information technologies (Karacaoğlu, 2018). As opposed to subject-centered pedagogy, the child's characteristics, interests, and needs are considered when designing learning environments. In so doing, students would have the opportunity to utilize their prior knowledge and past experiences to participate in the learning environment, which is deemed essential for active and meaningful learning. In this regard, the new curricula not only highly stressed the use of hands-on experiences, cooperative learning, and extracurricular activities, but it also encouraged teachers to utilize authentic assessment, highlighting the need to assess students holistically throughout the entire learning process via student portfolios, performance and project assignments, concept maps, self, and peer evaluations.

Embedded in these changes, neither the student is seen as the depositor, nor the teacher as the transmitter of the knowledge. In the new curricula, teachers are expected to facilitate learning by providing enriched learning opportunities that challenge students' minds as a prerequisite for seeking and structuring knowledge and building on their capacities. In turn, students are expected to take responsibility for their learning by drawing on their prior knowledge and hands-on experiences, actively participating in collaborative working environments, questioning, discussing, and sharing their ideas, solving problems, and making decisions (Bulut, 2007; Elmas et al., 2014; Koc et al., 2007; Kosar Altinyelken 2011, 2013; Kurtdede et al., 2014).

Nevertheless, despite high aspirations towards the particular curriculum change in Türkiye, the research has shown that there is a significant gap in practice between the intended and enacted school curricula in different subject areas (e.g., Akdeniz & Paniç, 2012; Altun & Şahin, 2009; Elmas et al., 2014; Kosar Altinyelken 2011, 2013; Yaşar & Sözbilir, 2019). This might be alarming since there should be a strong congruence between the intended and enacted curricula to discuss the success of any curriculum implementation; otherwise, the reform might conclude with an implementation failure. Drawing on the body of literature suggesting that teachers play a critical role in the enactment or implementation of curriculum change, this study focuses on teachers' attitudes towards curriculum change in the context of the Turkish education system and it attempts to explore the factors behind teachers' perceptions of their *self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change in understanding their attitudes towards the constructivist curriculum change*.

Teachers' Attitudes Towards Curriculum Change: The Role of Teachers' Readiness for Change, Self-Efficacy Beliefs for Teaching, and Beliefs about Teaching

Teachers have a fundamental role in successfully implementing curricula, which highlights the importance of how they perceive the reform (Kyriakides, 1997). Goodson (2000) asserts that the interplay between the external and personal change forces requires preserving a balance to reach success at the end of the implementation process. That balance between external and personal change might be only addressed by including teachers in the change process and being attuned to their beliefs, commitments, and professional efforts. For a successful change, Weiner (2009) also pointed out the need for understanding people's beliefs, attitudes, and intentions to figure out the necessity of change before bringing it into practice. From this perspective, it can be especially useful to explore teachers' readiness for change to understand why they adopt or resist changes in the curricula. Several

studies illustrated that teachers more often resist externally initiated changes (Du & Chaaban, 2020; Han, 2013; van Driel et al., 2001) and develop negative attitudes if the change does not correspond to their beliefs and values (Carless, 2013; Park & Sung, 2013). Teachers' resistance might generally stem from their non-involvement in the change process, lack of knowledge and support, experienced fear and uneasiness of the unfamiliarity, and concerns about losing their instructional habits (Cerit, 2013; Du & Chaaban, 2020; Kosar Altinyelken, 2013).

As teachers' beliefs directly influence their behaviors and intentions towards the curricula (Chen, 2015; Pajares, 1992; Roehrig et al., 2007), the curricular changes should also correspond to their belief systems, particularly their beliefs about teaching and self-efficacy beliefs for teaching. First, teachers' perceptions of the knowledge structure, the reality, and the ways they employ to fulfill students' interests and needs, including teacher-centered and student-centered approaches, constitute their beliefs about teaching. The literature generally focused on how teachers' beliefs about teaching are linked to their curricular change practices. In so doing, the findings put forth that teachers are mostly reluctant to employ the changes in curricula if the relevant changes do not correspond to their belief systems (e.g., Roehrig & Kruse, 2005; Roehrig et al., 2007; Yates, 2006). Second, teachers' self-efficacy beliefs for teaching refer to their capability judgments on arriving at the intended learning outcomes (Tschannen-Moran & Woolfolk Hoy, 2001). Accordingly, teachers with firmer self-efficacy are more open to using new instructional methods and strategies regarding the changes in the curricula. On the contrary, implementing the changes might be problematic if there are concerns about teachers' capability judgments (e.g., Çayak, 2014; Eskici & Özen, 2018; Ghaith & Yaghi, 1997; Kasapoğlu & Duban, 2012; Nie et al., 2013; Pan et al., 2013).

Research has shown that several factors, including the lack of support and knowledge about the change (Akdeniz & Paniç, 2012; Altun & Şahin, 2009; Bulut, 2007; Dindar & Yangın, 2007; Eraslan, 2013; Kosar Altinyelken, 2011; Yaşar & Sözbilir, 2019); the factors related to learning environments, such as class size and shortage of materials (Altun & Şahin, 2009; Bulut, 2007; Dindar & Yangın, 2007; Kosar Altinyelken, 2011; Yaşar & Sözbilir, 2019); parental attitudes towards the new curricula (Dindar & Yangın; 2007; Eraslan, 2013; Kosar Altinyelken, 2011); the presence of standardized examinations (Eraslan, 2013; Kosar Altinyelken, 2011; Yaşar & Sözbilir, 2019); and the ineffectiveness of in-service trainings (Altun & Şahin, 2009; Bulut, 2007; Dindar & Yangın; 2007; Eraslan, 2013; Yaşar & Sözbilir, 2019) were the most common issues impacting the implementation of the new curricula in Türkiye, which might, to some extent, interplay with teachers' beliefs. In fact, although teachers' beliefs and readiness have a place in how they perceive and implement the new curricula, altering the belief structures is not as easy as structuring the curricula (Fullan, 2016). That calls attention to investigating the factors underlying behind teachers' self-efficacy beliefs, teaching beliefs, and readiness for change as they shape their attitudes towards the implementation of curriculum change. To that end, situated in the context of the constructivist curriculum change in Türkiye, this study employs Bronfenbrenner's (1976) seminal framework, the experimental ecology of education, as a theoretical lens to explore the factors behind teachers' perceptions of their self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change in understanding how they influence teachers' attitudes towards the implementation of constructivist curriculum change.

Theoretical Framework: Ecology of Education

Drawing on Bronfenbrenner's (1976) seminal framework, the experimental ecology of education, as a theoretical lens to explore the ecology of curriculum change, the fundamental assumption underlying this study is that curriculum change is a complex process that requires considering multiple factors at multiple levels of an educational environment. The application of ecology as a holistic theoretical approach is crucial as teachers do not exist in isolation but are embedded within a larger social structure interconnected with other social institutions. Therefore, a non-linear, holistic view of curriculum change supports the adoption of the ecology of education as a framework for understanding the nested arrangement of several structures impacting the success of the enactment of curriculum change. Specifically, we use the earlier version of the theory, where Bronfenbrenner (1976) identifies five interwoven and interrelated contexts/systems in which an individual exists at the center: micro-system, meso-system, exo-system, macro-system, and chrono-system. These systems are useful in that they help understand a complex system with nested layers that are simultaneously interacting and leading to certain patterns of practice. While we acknowledge that Bronfenbrenner's theory of ecology of education has been in a continual state of development with the developed versions focusing on the Process-Person-Context-Time model (Bronfenbrenner, 1989, 1999, as cited in Tudge et al., 2009) and/or the neo-ecological theory highlighting the role of digital era (Navarro & Tudge, 2023), our study benefited from the earlier version as we did not specifically aim to focus on the process, person, context, and time elements of the teachers' perceptions of their self-efficacy beliefs for teaching, teaching beliefs, and readiness for change in understanding how they influence teachers' attitudes towards the constructivist curriculum change; nor did we seek to investigate the particular interactions or the interrelatedness among them within the scope of this study. We did not intend to situate our work specifically in the digital context either.

According to Bronfenbrenner (1976), first, the micro-system relates to an immediate setting in which individuals engage in particular activities in particular roles (e.g., teacher, student, parent, principal) for a certain time in a certain place (e.g., classroom, school). Second, the meso-system includes the interrelations among the multiple micro-systems. For a teacher, it typically encompasses interactions among parents, school, peer groups, administrators, and so on. Third, the exo-system refers to an extension of the meso-system that includes both formal and informal social structures and the major institutions of the society, such as the neighborhood, mass media, agencies of the government, and so on. Fourth, the macro-system is the largest and most

distant collection of people and places to the individual that nevertheless have major influences on them. The macro-system encompasses the larger economic, social, legal, and political systems as well as socio-cultural values and beliefs that both explicitly and implicitly shape the micro-, meso-, and exo-systems. Lastly, the chrono-system includes all environmental changes and historical events that take place throughout the lifespan and affect the individual (Bronfenbrenner & Evans, 2000).

To begin our thinking about curriculum change as a complex system, in our work, we adopted Bronfenbrenner's (1976) framework of the ecology of education to study what factors affect teachers' attitudes towards constructivist curriculum change. In so doing, we placed the main agents of curriculum change implementation (teachers) at the center of this complex and interactive system and wanted to explore their perspectives to better understand how participants view the factors influencing their self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change that subsequently facilitate or hinder the enactment of the curriculum change process, particularly within the context of a constructivist curriculum change that has taken place in the Turkish education system since 2005. Thus, we argue for a framework to think about teachers' experiences of curriculum change implementation more holistically, as such experiences cannot be comprehended adequately without exploring the interconnectedness between these multiple subsystems of social structure.

METHODS

Research Design and Participants

To uncover the lived experiences of the participating teachers in relation to the factors that affect their attitudes towards the constructivist curriculum change, the study employed phenomenological research (Creswell, 2013). The purpose of phenomenological research is to explore the perspectives and lived experiences of several individuals about the phenomenon of interest and reveal the commonalities across them (Marshall & Rossman, 2011). This rests on the assumption that the same phenomenon can be experienced and interpreted in multiple ways by different individuals (Merriam, 2014). Accordingly, this study was designed as qualitative phenomenological research to gain an insight into the world of teachers and reveal the commonalities across their experiences of implementing a mandatory and top-down constructivist curriculum change within a highly centralized K-12 education context in Türkiye.

The study included 21 participants, who were selected through maximum variation sampling (Patton, 1990) by considering their gender, educational background such as the type of the faculty graduated (education faculty or other), year of graduation, the highest degree obtained (two-year degree, bachelor's degree, and master's degree), and professional background including years of professional experience and the school level (elementary school, middle school, and high school). Building these variables into the participant selection process enabled us to capture the common themes that emerged from a great deal of variation and therefore contributed to the richness of the results (Patton, 1990). Certain demographic characteristics of the participants are presented in Table 1. Herein, it should be noted that while the socio-economic status (SES) of the schools was initially not among the participant selection criteria, based on the demographical questions on our interview schedule, we also obtained information regarding the SES of the schools by the participants' own descriptions provided in their interview responses. Understanding the broader ecological context of curriculum change requires considering school level, socio-economic status, and class size. These factors offer a nuanced perspective on how teachers' experiences with constructivist curriculum change might differ across various educational settings, thereby enhancing the study in multiple ways. First, those variables help illustrate how the implementation of the 2005 curriculum change was experienced differently in the school environment. For instance, teachers in resource-limited schools, particularly in low SES settings, might have faced greater challenges in adapting constructivist teaching methods compared to those in well-resourced ones (Dönmez & Akar Vural, 2014; Gömleksiz & Öner, 2013). Additionally, students' readiness and parental involvement in education vary across SES levels, which might be influential on the constructivist curriculum implementation. Second, class size and school SES have a direct impact on teachers' self-efficacy beliefs and their readiness for change. Larger class sizes, for example, may hinder the effective adoption of student-centered teaching approaches, while schools with higher SES might have access to professional development opportunities, as supported by several studies (Bal & Doğanay, 2009; Yiğit et al., 2017). It is imperative that teachers receive successful teaching experiences facilitated by full access to teaching resources and pay more individual attention to students in small classes, as this can greatly influence their confidence in effectively implementing the constructivist curriculum and ease their transition to these necessary changes. By including these variables, the study does not merely focus on the historical moment of curriculum change but also considers its ongoing impact. Understanding how these factors continue to shape teachers' experiences provides insights into the sustainability of curriculum change over time. Therefore, the richness of the study lies in its ability to capture a diverse array of experiences across different school environments by including school level, SES, class size, and the other variables. By exploring how these conditions shaped teachers' responses to curriculum change, the study intends to offer a more comprehensive view of the challenges and successes of curriculum changes.

Table 1. The demographic characteristics of the participants

		Gender	Type of faculty graduated	Highest degree obtained	School level	Socio-economic status of the school	Class size
Participants of the Main Study							
	Teacher D	Female	Education	Master's	Primary	Low	35
	Teacher E	Female	Other	Bachelor's	High	Middle-Low	40
	Teacher F	Female	Education	Bachelor's	Middle	Middle	28
	Teacher G	Female	Education	Master's	Middle	Middle	10
	Teacher H	Female	Education	Bachelor's	Middle	Middle	32
	Teacher I	Male	Other	Associate	Primary	Middle-High	30
	Teacher J	Female	Education	Bachelor's	Middle	Middle-Low	24
	Teacher K	Female	Education	Bachelor's	Middle	Middle	30
	Teacher L	Female	Other	Bachelor's	High	Middle-Low	25
	Teacher M	Female	Education	Bachelor's	High	Middle-High	20
	Teacher N	Male	Education	Bachelor's	Middle	Middle	29
	Teacher O	Male	Education	Bachelor's	High	Middle-Low	35
	Teacher P	Female	Other	Bachelor's	Primary	Middle	30
	Teacher R	Female	Education	Bachelor's	Middle	Middle	15
	Teacher S	Male	Education	Bachelor's	Middle	Middle-Low	30
	Teacher T	Female	Education	Bachelor's	Middle	Middle	30
	Teacher U	Male	Other	Bachelor's	High	Middle	33
	Teacher V	Male	Education	Bachelor's	Primary	Middle	32
	Teacher X	Female	Other	Bachelor's	Primary	Low	22
	Teacher W	Male	Other	Bachelor's	Primary	Low	17
	Teacher Z	Male	Education	Bachelor's	Middle	Middle	33
Participants of the Pilot Study							
	Teacher A	Female	Education	Master's	Pre-school	Middle	25
	Teacher B	Male	Education	Bachelor's	Primary	Low	21
	Teacher C	Female	Education	Bachelor's	Primary	Low	32

Data Collection Procedure and Analysis

As the data collection in phenomenological studies typically relies on in-depth interviews (Marshall & Rossman, 2011) to enter into the world of participants (Patton, 1990) and obtain descriptive data in their own words (Bogdan & Biklen, 2007), the data in this study were collected through in-depth individual interviews with the participating teachers. To this end, a semi-structured interview schedule was developed by the researchers. The interview schedule consisted of both demographical (e.g., gender, age, subject-area, educational background such as the year of graduation, type of the faculty graduated, highest degree obtained, professional background such as professional experience) and also five open-ended questions that are coupled with probes and prompts (e.g., "How do you feel about being ready for change, especially in relation to the constructivist curriculum reform? What might be some factors affecting your readiness for change? i.e., parent-related, curriculum-related, school-related, student-related). Once the interview schedule was developed, it was revised based on the opinions of two experts who are specialized in teacher education and experienced in qualitative research. Then, a pilot study was carried out with three teachers to check the appropriateness and the flow of the questions and test the length of the interview.

The main data collection was done through 21 semi-structured individual interviews with the participants over three months in the fall semester of the 2020-2021 academic year. Considering the COVID-19 pandemic guidelines, all interviews were conducted online. Each interview lasted 30 to 35 minutes on average, was audio-recorded by ensuring the participants' permission, and transcribed verbatim. The anonymity and confidentiality of the participants' personal information were ensured by using pseudonyms (e.g., Teacher G).

The data were analyzed by content analysis method that involved a process of inductive coding (Bogdan & Biklen, 2007; Patton, 1990), and then was followed by deductive coding according to the theoretical framework applied in the study. First, we used certain codes to aggregate the data into smaller parts (Miles & Huberman, 1994). Then, we identified common patterns among the codes in each transcript and generated larger categories across all transcripts. To develop an initial code list, a sample of three transcripts was coded by the researchers. Then, the initial code list was revised based on the discussions and consensus between the two researchers, which helped establish intercoder reliability and increased the consistency of the codes and categories (Miles & Huberman, 1994). Throughout the data analysis process, the researchers continued to meet regularly to discuss the emerging codes and categories (see Table 2 for sample thematic coding). Lastly, to present the findings in participants' own words, sample quotations were selected and translated from Turkish to English.

Table 2. Sample thematic coding

Quote	Codes	Subtheme	Theme
The colleagues around me influence my teaching beliefs the most. We tell the students, 'you are the average of your friend groups.' We are also the average of our colleagues. If teachers are willing to change their environment during the implementation of the change, we become more positive and say, 'Let's do this for our children.	Interactions among colleagues	School-related factors	Micro-System and Meso-System related factors
"I have attended countless in-service training seminars, but only one has left a lasting impression on me. The others felt meaningless. When the presenters come in and say, "We know as much as you do," it signals the end of any real engagement. Many of them are in the same position; the person speaking to me is often not more effective or knowledgeable than I am, and they are not someone who can provide real value. They have been assigned to fulfill a task rather than inspire. When I encounter such a person who approaches me this way, I don't feel compelled to listen. However, if the presentation were prepared with genuine conviction, delivered by knowledgeable individuals who truly respect the audience, it would be far more beneficial. Unfortunately, this is rarely the case.	The quality of professional development activities	Education-system related factors	Macro-System related factors

Trustworthiness

To establish the trustworthiness of the study, we employed multiple strategies (Lincoln & Guba, 1985; Marshall & Rossman, 2011). Specifically, as for the credibility of the study, we consulted two experts specialized in teacher education to share their opinions on the interview schedule, and also conducted a pilot study prior to the main data collection to ensure that the interview schedule worked as intended. Moreover, conducting in-depth interviews with the participants, engaging with the data throughout the data collection and analysis processes over one year, and the intercoder reliability processes contributed to the enhancement of the credibility of this research. Furthermore, to establish referential adequacy in documenting the findings, sample quotations from the participants were presented. Regarding transferability, the study employed purposive sampling, as explained in the participant selection procedure. In addition, a thick description was utilized by describing the overall research process in detail, especially concerning the decisions about the design of the study, the selection and background of the participants, data collection, and data analysis.

Researcher Positionalities

Reflexivity is a central tenet of qualitative research as the positioning of the researchers in relation to the context of the study affects every phase of the research process. Accordingly, the first author is a teacher educator and a curriculum specialist in Türkiye, whose scholarly interests include curriculum studies, curriculum change, curriculum development, implementation, and evaluation. Her educational and professional experiences both in centralized and decentralized education systems in several countries allowed her to develop a scholarly interest in the successful implementation of curriculum change. The second author is also a teacher educator and a curriculum specialist in Türkiye, whose research interests include curriculum development and curriculum evaluation. Her scholarly work and professional experiences in curriculum development and implementation processes expanded her theoretical and methodological arsenal in studying successful curriculum change practices.

FINDINGS

Utilizing Bronfenbrenner's ecological theory, the results of this study showed that teachers mainly discussed the influence of the micro-system-, meso-system-, exo-system, and macro-system-related factors on their self-efficacy beliefs for teaching, beliefs

about teaching, and readiness for change in relation to their attitudes towards the implementation of the constructivist curriculum change. As they did not make any connections to the factors related to the chrono-system, we aimed to provide an in-depth analysis of their responses by focusing on the four systems mentioned above alongside placing the teachers and thereby teacher-related individual factors at the center. Specifically, our results revealed the following categories: a) Teacher-related factors; b) Micro-system-related and Meso-system-related factors; c) Exo-system-related factors; and d) Macro-system-related factors (see Figure 1). These categories portray teachers' lived experiences in each subsystem, reflecting the impact of these factors on their attitudes towards implementing constructivist curriculum change.

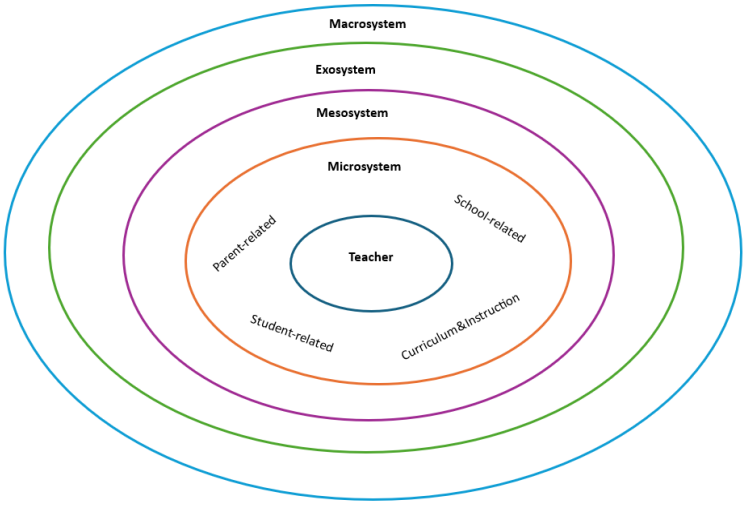

Figure 1. Ecology of curriculum change. (Adapted from Bronfenbrenner's framework of the ecology of education)

Individual System: Teacher-Related Factors

Applying Bronfenbrenner's (1976) framework of the ecology of education in the context of curriculum change, we found that teachers' educational backgrounds, feelings, values, characteristics, and experience are central to the ecology of constructivist curriculum change for a successful implementation, which forms the individual level. Many participants asserted that educational background and teaching experience are influential in shaping teachers' self-efficacy beliefs for teaching. Considering educational background, some teachers stated that they had received their bachelor's degree after the curriculum reform in 2005 and this made it easier for them to adapt to the curriculum change as the teacher education programs in Türkiye have been aligned with the constructivist approach since then. In addition, some teachers explained how obtaining a graduate degree improved their self-efficacy beliefs for teaching, consequently impacting their attitudes towards implementing the constructivist curriculum. For example, Teacher G described her "self-efficacy as higher after master's and doctoral education because one gets the chance to reflect on what they have learned in their teaching. So, they actually realize what they are doing." In this regard, graduate education seems to have an awakening role in Teacher G's position as a teacher and a curriculum maker/developer. In addition, Teacher G continued to explain how her teaching experience also shaped her self-efficacy beliefs for teaching by stating "As you gain experience, you develop yourself professionally and your self-efficacy starts to increase." As illustrated by Teacher G, teaching experience adds to teachers' professional growth and makes them more capable of implementing the intended curricular changes, which thereby influence their attitudes towards implementing the constructivist curriculum. Moreover, as for teacher characteristics, the participants especially stressed the role of being open to development and change especially in terms of participating in professional development activities and following the publications about constructivism as these made a strong impact on their self-efficacy beliefs for teaching and influenced their attitudes towards implementing the constructivist curriculum. Furthermore, teachers expressed that their motivation and knowledge about the constructivist approach also influenced their self-efficacy beliefs for teaching. For example, Teacher O commented, "I feel incompetent at implementing the constructivist approach… I was not provided with the necessary academic knowledge in this regard. That is the biggest problem on this matter [self-efficacy]!" Here, Teacher O evaluated his current knowledge and skills about the constructivist approach and reflected on his lack of adequate knowledge as a concern for his self-efficacy beliefs for teaching, subsequently affecting his attitudes towards implementing the constructivist curriculum.

Similar to teachers' self-efficacy beliefs for teaching, our findings revealed that teacher characteristics, as well as their level of motivation, teaching experience, and knowledge about the constructivist approach also impacted their general beliefs about teaching. Some teachers further addressed the essential role of one's expertise in their field in terms of professional knowledge, skills, and attitudes as they shaped their general beliefs about teaching. For instance, Teacher E criticized her lack of professional knowledge and skills when she said:

> Indeed, many teachers lack professional knowledge and skills in their area and also about the changes in educational systems...Personally, the most important problem I experience with this [constructivist curriculum] change is that I cannot perform professionally enough. That

> is, I don't feel fully equipped in terms of the necessary knowledge and skills; and therefore, my beliefs as well as my pedagogical approach might not be fully constructivist.

As seen, teachers' professional knowledge, skills, and behaviors play a significant role in employed approaches in classes which necessarily mediate their general beliefs about teaching; and therefore, influence their attitudes towards implementing the constructivist curriculum at the individual level. Third, concerning teachers' readiness for change, not only teacher characteristics, educational background, and their level of motivation, but also emotional readiness at the individual level was deemed critical for their attitudes towards the constructivist curriculum change. Specifically, this included teachers' feelings, as illustrated in the words of Teacher G, who addressed the difficulty of experiencing a lot of uncertainty in the process of curriculum change and showed a low level of emotional readiness:

> You leave the system you are accustomed to and adopt a new one. Therefore, you will start from the beginning and have to study for the unknown, so it is quite worrying in terms of whether I can manage it or not.

Similarly, Teacher L shared how teachers' feelings influence their readiness to implement the changed curricula by articulating, "I may think that 'Ok! I learned this and will implement it, but then I may feel challenged and not be able to internalize it or communicate it to the student." As seen, although Teacher L reflected on her high cognitive readiness, she explained that she did not feel comfortable enacting the curriculum change, especially when encountering difficulties. As reflected in her expressions, emotional readiness for the intended curriculum changes might become critical for teachers to be able to put them into practice successfully.

Micro-System-and Meso-System-Related Factors

In understanding the factors influencing teachers' self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change, which ultimately facilitate or hinder the implementation of the constructivist curriculum change, the micro-systems of the current study yielded the complex relations between teachers and the environment in which they are surrounded with, including factors related to curriculum and instruction, students, parents, and the school. That is, the K-12 school curricula, students, parents, colleagues, and school principals constitute the immediate settings of teachers, where each component has a particular role in particular activities. Moreover, following the micro-system, the meso-system in our findings pointed to the dynamic interplays between the micro-systems and the teacher.

In relation to the micro-system of the constructivist curriculum change, teachers largely complained about the elements of the new K-12 school curricula. They discussed the density of the number of objectives, the complexity and abundance of content, and the limited time allotted to cover them as the most important factors, especially in terms of affecting their self-efficacy beliefs for teaching and their readiness for change, which consequently influenced their attitudes towards the implementation of the intended curricular change. For example, Teacher E discussed the high number of objectives as an obstacle to the successful implementation of the constructivist approach within the given amount of time:

> ...You should see the 9th-grade curriculum. You cannot finish it even if you cover all the content without any pause. Impossible! The texts are too long due to the constructivist approach. This process makes me feel unsuccessful and incompetent.

Here, Teacher E addressed the tension teachers experienced in trying to cover all the objectives and information in the curriculum and textbooks in the allocated time. Similarly, Teacher T underscored the abundance of content negatively influencing her readiness for change and mentioned, "...There are too many topics and the curriculum content is highly intense. The most important reason for me to feel resistant to this change might be this." Concerning this, Teacher K talked about the insufficient time affecting her readiness for the change and continued, "…just adequate time should be given to me during the class. Then, I would be open to any change that provides the child with time to think and construct knowledge." As such, teachers criticized how the number of objectives, the content, and the time to cover them altogether inevitably affected their self-efficacy for teaching and readiness for change negatively to implement the constructivist curriculum.

Moreover, teachers reflected on the structure of the centralized K-12 curriculum concerning its unfeasibility and inflexibility as these made an impact on their self-efficacy beliefs for teaching and further affected their attitudes towards the intended curricular change. In a centralized curriculum, the decisions related to all components of the curriculum are taken by a central national office, which is the Ministry of National Education (MoNE) in the context of Türkiye. Then, that same curriculum is implemented in all schools across the country. While this makes it easier for the government to control and monitor the curriculum development, implementation, and evaluation processes, it leaves less room to be responsive to the local needs and allows low flexibility and autonomy on the part of teachers. Accordingly, Teacher I complained about the unresponsive and inflexible nature of the centralized curriculum and explained how this hinders teachers' self-efficacy for teaching in implementing the constructivist curriculum in their classes:

> …The curriculum implementation guide is sent to all cities such as İzmir, Ağrı, Sinop, Mersin, and so on [cities across different regions of Türkiye]. Yet, the teachers working in Nişantaşı [ahigh SES urban neighbourhood in İstanbul] and the teachers working in a village in Ağrı [a rural city in Türkiye] are using the same guide. Is this plausible? The conditions, such as students' readiness level, are completely different, but the expectation from the teachers is the same. This eventually prevents teachers, first, from developing themselves professionally and thus lowers their self-efficacy, causing them to be ineffective in the implementation.

Thus, teachers might feel urged not to fall behind the curriculum and focus on the content, not the students, despite it being a constructivist change. Furthermore, with respect to their beliefs about teaching, teachers foregrounded attention to the design of the curriculum, including the content and instructional methods/strategies. For example, Teacher D stated, "What topics are covered and how those are expected to be taught definitely influence my beliefs and my instructional decisions as a teacher. I mean, they certainly influence my philosophy of education." Teacher D expressed that the content and the methods to be utilized in the constructivist curriculum seemed to affect her beliefs about teaching, which might also have impacted her attitudes towards implementing the intended curricular change. In addition, Teacher T highlighted the nature and the complexity of the content in some disciplines as those influenced teachers' beliefs about teaching: "For example, there are some topics in the mathematics curriculum. Waiting for students until they construct knowledge might be time-consuming. Therefore, the traditional [teacher-centered] approach might work better for those topics in the curriculum." Given this, content might be another significant factor shaping teachers' general beliefs about teaching and thereby influencing their attitudes towards implementing the constructivist curriculum.

In addition to the curriculum-related factors, second, the results revealed certain student-related factors in the micro-system of the constructivist curriculum change. In particular, teachers mostly stressed the changing student profiles, students' readiness and achievement levels, engagement, and motivation as the most important factors that affected their attitudes in implementing the constructivist curriculum. For instance, some teachers mentioned how Gen Z students' changing interests and technological qualifications influenced their self-efficacy beliefs for teaching. To illustrate, Teacher G shared her anxiety and said, "As you get older, the generation differences become sharper, so you feel worried about your competence. I mean, as the children raised with technology are different from your generation, you don't know how to address their educational needs." As such, the changing student profile, especially with the advancement of technology, might deepen teachers' capability judgments in responding to students' needs and interests in the constructivist curriculum.

Teachers also made connections between students' readiness or achievement levels and their general beliefs about teaching, as these consequently affected their attitudes towards implementing the constructivist curriculum. For example, Teacher E articulated:

> Because of students' lack of prior knowledge, sometimes I feel like I am solving all those math problems in another language. Then, I intentionally prefer using traditional methods. On the other hand, sometimes I see that students have the prerequisite knowledge. When I see that, I put them at the center of the learning process.

Here, Teacher E addressed the dynamic interaction between the teacher and students, particularly emphasizing students' readiness level. Similarly, Teacher M drew attention to students' lack of prerequisite knowledge:

> Today, I taught a lesson on string in class. Ideally, string should be covered in middle school, but this child came without any prior knowledge. I'm not sure about how to approach the situation. Should I follow the curriculum as planned? Should I talk with him to gauge his understanding? Should I try to comfort him psychologically? It seems that none of these options may be effective. We can't proceed with the lesson as outlined in the curriculum, and it's beyond our control.

Accordingly, students' level of knowledge shapes teachers' general beliefs about teaching and makes an impact on their teaching methods while implementing the constructivist curriculum. Moreover, students' socio-economic backgrounds and socio-cultural beliefs affected teachers' beliefs about teaching, eventually shaping their attitudes towards the constructivist curriculum. Such factors are also vivid examples of the meso-system, showing the interactions between the teacher and the other elements of the micro-system of the constructivist curriculum change process, such as students. To illustrate, Teacher J shared an example of the interaction between herself and her students where she emphasized the influence of the social setting in which the school was located and the students were raised:

> …The school's social environment and the students' beliefs and attitudes about things also influence our attitudes towards curriculum implementation. For example, as a science teacher, I have to teach them the concepts of mutation and evolution. However, students say, 'it is not possible; God created everything!' and then they develop a negative attitude towards the class. I insist that this is a science class, not necessarily a religion-related class… So, with the help of different questions and strategies, you try to make them think differently and offer different insights or thoughts.

Apparently, students' beliefs and values are influenced by their socio-cultural environment (in connection to their exo-system), which challenges teachers' ways of teaching and their beliefs about teaching in implementing the constructivist curriculum. Except these, students' academic progress and outcomes also seemed to be another critical factor for some teachers while evaluating their beliefs about teaching to implement the intended curricular changes. For instance, Teacher N said, "First, I wonder whether the new curriculum works well. If yes, what are the results? Have students performed better? Then, it might be used." Hence, teachers essentially reflected a desire to know the actual outcomes of the curricular change on the basis of students' academic performance, as these were important for tailoring their general beliefs about teaching and consequently shaped whether or not they would show interest in implementing the intended change.

Third, considering the parent-related factors, our results yielded that the interfering behaviors of parents, as well as their knowledge about the constructivist curriculum and involvement in the education of their children seemed to have a significant impact on teachers' self-efficacy beliefs for teaching and their general beliefs about teaching in implementing the constructivist

curriculum successfully. For instance, Teacher C shared her discomfort with the interfering behaviors of parents, which negatively shaped her self-efficacy for teaching to implement the new curriculum:

> Unfortunately, some parents are not open to change… For example, the parent might react in a negative way when we read a story about a pig. The idea of a pig in the curriculum is not appropriate for them for different reasons, and they impose this on the child. Then, the child would not be open to anything… You would like to include the child in the activities, but the parent might hinder this. These certainly affect my self-efficacy and limit the things I can use in class.

As seen above, in the meso-system, the interplay between the teacher and the elements of the micro-systems of the constructivist curriculum change process, such as parents' interfering behaviors, influence students' behaviors in the learning process, which seemed to affect teachers' self-efficacy beliefs for teaching and their classroom practices negatively in implementing the constructivist curriculum. Similarly, parental involvement played an important role in shaping teachers' beliefs about teaching, subsequently affecting their attitudes towards implementing the constructivist curriculum. To illustrate, Teacher L talked about how parents' interests in their children's education influence her beliefs about teaching:

> I worked at two different schools in the same academic term. Considering the curriculum implementation, my motivation and instructional strategies were different because students' motivation was different, which was, to a large extent, related to their parents and parental involvement. How parents value education, how they get involved in their children's education and care about this etc. make a considerable influence on the way I teach my classes.

Here, Teacher L addressed that parental involvement or one's level of interest in their children's education has a significant role in teachers' selection of the teaching methods and tailoring their attitudes to implement the constructivist curriculum successfully.

Fourth, considering the school-related factors, the school and its key elements, such as its physical features, participants and their roles, constitute the final component of the micro-system of the constructivist curriculum change process. Specifically, teachers underscored the physical and technological conditions of schools, including their resources, materials, and facilities, as critical factors that impact their self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change, which subsequently, shape their attitudes towards implementing the constructivist curriculum. For instance, teachers mentioned large class sizes as jeopardizing their self-efficacy beliefs and general beliefs about teaching in implementing the constructivist curriculum. To illustrate, Teacher E stated:

> I cannot say that I am fully implementing all the methods and techniques suggested by the constructivist approach. I try to employ those techniques and methods as much as I can. In this curricular change, you are expected to interact with each child and help them engage in group work, but the class sizes are around forty students. Students should interact with each other in small groups, but we cannot do this. The main problem is not that I don't know the constructivist approach well, but it is related to the physical conditions which challenge me to implement those expectations truly. Suppose that the class size is twenty students; then you can better implement the constructivist curriculum.

As seen, large class sizes burden teachers, negatively affecting their evaluation of their competence and the ways to implement the curriculum. Consequently, that affects teachers' attitudes towards implementing the constructivist curriculum. In addition to the physical and technological conditions of schools, school principals and colleagues play a key role in teachers' immediate settings and are critical to their self-efficacy beliefs, beliefs about teaching, and readiness for change to implement the constructivist curriculum successfully. Teachers especially discussed the attitudes of school principals in terms of whether they encourage the implementation of the curriculum or create pressure on teachers due to reasons such as being uncommunicative and ignorant of teachers' needs during the implementation process. Similarly, colleagues' attitudes and interactions were deemed crucial for teachers' self-efficacy beliefs for teaching and their general beliefs about teaching, consequently making an impact on teachers' attitudes towards implementing the constructivist curriculum. To illustrate, Teacher L articulated how her colleagues' attitudes and their mutual interactions affected her beliefs about teaching:

> The colleagues around me influence my teaching beliefs the most. We tell the students, 'you are the average of your friend groups.' We are also the average of our colleagues. If teachers are willing to change their environment during the implementation of the change, we become more positive and say, 'Let's do this for our children.

Thus, teachers discussed how collaborative work or positive attitudes towards any intended change among colleagues would contribute to their teaching beliefs, leading to the successful implementation of the curricular change. On the other hand, colleagues' habitual educational practices seemed to negatively influence teachers' readiness for the change. As a counterexample, however, Teacher C exemplified how her colleagues' commitment to their educational habits and practices whenever a change in curriculum occurs positively affected her readiness for the curriculum change:

> Some teachers are about to retire. They might be qualified teachers, but they make no progress whenever new innovative and technological approaches come in. Whenever I observed them, I decided I should not adopt such attitudes, so I decided to welcome such new [constructivist] approaches and the resulting changes in pedagogy [constructivist learning-teaching approaches].

Exo-System-Related Factors

An exo-system is a broader extension of the meso-system that includes various formal and informal social structures, such as neighborhoods, mass media, and local, state, and national government agencies. Those structures do not directly affect the individual but rather surround the immediate environment in which the person exists (Bronfenbrenner, 1977). Expanding on the

elements influencing teachers' self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change in implementing the constructivist curriculum change, we identified that the socio-cultural environment in which schools are situated and teachers work, as well as mass media served as sub-themes of exo-system. For example, Teacher C underlined the key role of the socio-cultural environment where she has been working in affecting her beliefs of teaching, which subsequently influenced her attitude towards implementing the constructivist curriculum:

> The location where you work is a crucial factor affecting my teaching beliefs. I'm not referring to cities specifically; various socio-economic statuses can exist even within the same city. I have previously worked in the Black Sea region; I have also worked in a village where people do not speak Turkish. I can tell you from my experience in various environments that the neighborhood and the place surrounding the school definitely make a big difference.

Teacher C's perspective illustrates that the socio-cultural environment of her school significantly influences her beliefs about teaching, which is a crucial factor in implementing the constructivist curriculum. Besides, teachers also mentioned that mass media became influential in their beliefs about teaching, especially regarding the implementation of a constructivist curriculum. For example, Teacher L explained how mass media plays a critical role in shaping their beliefs while applying the constructivist curriculum by stating "The press plays a significant role in shaping my belief in teaching. The press always devalues teachers, talks about their salaries, shows incidents of violence, or obsesses about headscarves." As such, Teacher L emphasized the significant impact of mass media by highlighting negative incidents or drawing attention to various other factors that influence her beliefs about teaching, particularly in relation to implementing the constructivist curriculum.

Macro-System-Related Factors

According to Bronfenbrenner's framework of the ecology of education (1976), the formal and informal structures, including educational policies, social, economic, legal, and political systems that encompass the settings teachers are involved in, form the macro-system-related factors. Elaborating on the factors affecting teachers' self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change in implementing the constructivist curriculum change, we found that the structure and operational problems of the education system, the financial status of teachers, the design and quality of professional development activities, and the shortfalls of teacher education programs constituted the sub-themes at macro-system level.

First, concerning teachers' beliefs about teaching and self-efficacy beliefs for teaching, teachers pointed out the structure and operational problems of the education system, such as the implementation pressure and yet the lack of psychological support from the ministry, the presence of a strong organizational hierarchy, the changing nature of the system vs. neglecting teachers' decisions, all of which consequently affected their attitudes towards implementing the intended change. For example, Teacher P complained about the neglecting manner of the ministry for taking teachers' opinions and voices in the curriculum design process as an important factor influencing her beliefs about teaching, which therefore, affected her attitudes towards implementing the constructivist curriculum:

> The people in the ministry look at everything from the top and think that everything might be changed, but we experience difficulties when implementing the new curriculum. They shouldn't ignore these difficulties and give a voice to teachers. For example, we frequently prepare and submit reports that this curriculum is not appropriate for children because of X, Y, Z reasons, the textbooks are not suitable for the development level of the children, and we pinpoint the mistakes in the textbooks. However, no action is taken to improve the things that we recommend. Then, I try to find my own solutions in this process. For instance, I decided not to make use of anything in the curriculum that is not relevant to my students' developmental levels.

Parallel to this finding, teachers also mentioned that the top-down structure and the inadequate explanation of the introduced change influenced their readiness for change to implement the constructivist curriculum. For instance, Teacher M highlighted the negative effect of the top-down reform on her readiness for the change and stated, "The change should take place after asking teachers' opinions and suggestions. Do most teachers think that this change is necessary and useful? No one will be open to change when the change is imposed on them." Teacher M criticized the sudden changes in the curriculum where teachers are not involved in the design and initiation of change in a top-down fashion. Supporting this finding, Teacher L underscored the inadequate explanation of the change and insufficient support, which might create ambiguousness among teachers as a threat to their readiness for the change:

> We don't know what to do if the change is introduced as bothering, fearful, unknown, and unclear. In general, every change brings fear, and so teachers might doubt that they don't sufficiently figure it out. Then, how can they [teachers] enact the change? I think the immediate and top-down changes are, from the beginning, explained suddenly and quite superficially to the people who, then, introduce and explain those changes to us. Consequently, those people explain those changes very superficially too. Eventually, it ends up that everything is only expected from teachers without sufficient training and support.

As reflected in Teacher L's expressions, unclear expectations from teachers regarding the changes in the curriculum might not be instrumental to help clarify the questions in teachers' minds and impact their readiness in a negative way while implementing the intended curricular change. Moreover, teachers largely agreed that the financial status of teachers in Türkiye is another important factor negatively influencing their self-efficacy for teaching, beliefs about teaching, and readiness for change in implementing the constructivist curriculum. That is, most teachers drew attention to their living conditions and the financial costs of reaching basic educational sources and materials, such as having a personal computer or buying books. Teacher I indicated how his financial status affects his self-efficacy for teaching especially when it comes to implementing the constructivist curriculum:

> The living conditions of teachers are terrible. For example, I cannot buy a new laptop, so I cannot access the relevant sources that might be important for my classes that are expected to be student-centered. That negatively influences my entire approach to teaching and learning and hinders me from developing confidence and skills to implement the curriculum.

Indeed, Teacher I described how teachers, in general, are deprived of reaching relevant resources and pedagogical tools. While teachers mainly expected the necessary professional development support and opportunities from the ministry, we saw that they also felt urged to invest in improving their capabilities by themselves. Otherwise, we noted that it poses a threat to their self-efficacy and might further affect their attitudinal behaviors towards implementing the constructivist curriculum change.

Teachers also brought attention to the quality and the design of professional development activities or in-service trainings as these impacted their self-efficacy beliefs for teaching, beliefs about teaching, and readiness for change. In particular, they criticized the issues related to knowledge-centeredness, duration, planning, and instructors' qualifications when describing the quality and design of those activities, which are developed and implemented in Türkiye centrally by the MoNE. For example, Teacher D illustrated how the flow and the structure of the professional development activities aimed at introducing constructivist curriculum change were not suitable for gaining mastery experiences, which in return, influenced her self-efficacy beliefs:

> In professional development activities, one instructor usually comes, opens a power-point presentation, and delivers a talk. Then, an exam is given, and the training finishes. In this way, constructivism is only explained traditionally. I think teachers should be engaged in this process through different activities; they might plan a lesson and discuss it together each week. The instructor should demonstrate what we can do differently. I believe there should be some real opportunities to improve our ability to translate constructivism into our lessons.

Teacher D's expressions reflect her dissatisfaction with the ongoing professional development activities and exemplify the apparent mismatch between the adopted approach and its implementation in spaces where teachers are supposed to be provided with the opportunity to learn how to implement constructivism successfully. Teacher I also expressed concerns about the qualifications of the instructors leading the in-service training on the constructivist curriculum. This lack of qualified training hindered Teacher I from acquiring the necessary knowledge and skills needed for effectively implementing the curriculum and gaining mastery in his teaching experiences.

> I have attended countless in-service training seminars, but only one has left a lasting impression on me. The others felt meaningless. When the presenters come in and say, "We know as much as you do," it signals the end of any real engagement. Many of them are in the same position; the person speaking to me is often not more effective or knowledgeable than I am, and they are not someone who can provide real value. They have been assigned to fulfill a task rather than inspire. When I encounter such a person who approaches me this way, I don't feel compelled to listen. However, if the presentation were prepared with genuine conviction, delivered by knowledgeable individuals who truly respect the audience, it would be far more beneficial. Unfortunately, this is rarely the case.

Teacher I's critique of professional development activities, which were provided and indeed required by the MoNE, highlighted the instructors' lack of competence or efforts to provide authentic examples, guidance on do's and don'ts, and good practices for implementing the constructivist curriculum. As a result, this might increase the risk of failure in implementing the constructivist curriculum unless teachers find an opportunity to internalize the basic principles of constructivism during the centrally implemented nation-wide professional development activities, constituting a substantial component of the macro-system. Some teachers also raised self-efficacy issues due to the lack of role models displaying how to implement the constructivist curriculum. Teacher M, for example, highlighted the need to observe some experts before and throughout implementing the change and said:

> …An expert might come to our classes and explain how the course might be better aligned with the new constructivist curriculum. Then, we can build on this and try to create our own way, but we first need to learn by observing, as I don't feel confident otherwise.

Teacher M stresses the need to observe the practices of an expert before implementing the intended curricular changes in their classes. That would affect her self-efficacy beliefs towards implementing the constructivist curriculum. Teachers also addressed the common shortfalls in teacher education programs, such as the excessive focus on the theoretical aspects rather than the pedagogy and practice. These might have a negative impact on their self-efficacy for teaching and shape beliefs about teaching in a negative way when they try to implement the intended curricular change successfully. For instance, Teacher A criticized the insufficient time allocated for practicum courses in teacher education programs and stressed how those courses would be useful for teachers' self-efficacy to implement the constructivist curriculum. Particularly, Teacher A said, "I think there should be more practicum courses in the teacher education programs and more time for school placements and student teaching. As you observe the reality and gain first-hand experience, your efficacy tends to increase much more." Although teacher education programs are not within the immediate settings in which teachers themselves are involved in their everyday lives after graduation, those programs might influence teachers' self-efficacy for teaching by providing invaluable curriculum practices during pre-service education. Then, teachers' attitudes towards the constructivist curriculum change might be more positive when they start their teaching careers.

DISCUSSION

This study was conducted in the light of Bronfenbrenner's Ecological Theory (1976) in order to portray the ecology of curriculum change by exploring the factors underlying teachers' perceptions of their self-efficacy beliefs for teaching, general teaching beliefs, and readiness for change, which have been shown to be significant predictors of teachers' attitudes towards the constructivist curriculum change in the Turkish education context. By drawing on insights from Bronfenbrenner's ecological

systems theory, this study yielded a more comprehensive and holistic understanding of the factors influencing the success of curriculum change implementation that are nested in the following interwoven and interrelated systems with teachers placed individually at the center as agents of change: micro-system, meso-system, exo-system, and macro-system. While the teachers in our study made powerful connections to several factors in those four systems or contexts, we also acknowledge that they did not address the factors that might be important in the chrono-system (Bronfenbrenner, 1976) of the ecology of curriculum change implementation.

First, at the *individual level*, we found that teachers' educational background, teaching experience, knowledge, skills, motivation about the content of change (constructivist approach), and certain teacher characteristics, such as being open to development, are influential in their self-efficacy beliefs for teaching; and therefore, make an impact on their attitudes towards implementing the constructivist curriculum. Those factors seemed to contribute to the mastery experiences of teachers, deemed to be the most substantial source of self-efficacy (Bandura, 1997). As asserted by the social learning theory, individuals' mastery experiences in the form of personal accomplishments or failures shape their self-efficacy beliefs (Bandura, 1977, 1982, 1997). In our case, the increase in the teaching experience over the years, studying further through a graduate-level degree, and possessing the knowledge and skills about the change seemed to feed teachers' enactive experiences towards the constructivist curriculum, leading them to feel more competent towards implementing this change in their classes. The literature also supported the findings that different teacher characteristics, such as accumulated experience in teaching (Cheung, 2008; Veyis, 2020; Wolters & Daugherty, 2007) and the educational background (Ocak et al., 2017) increased teachers' competency beliefs towards working on any designated task or applying changes or innovations in education.

Our findings indicated that teaching experience, motivation, and professional knowledge, skills, and attitudes about the content and nature of change also impact teachers' general beliefs about teaching. Several studies found that teachers' educational background and teaching experiences were critical in forming and shaping their beliefs (Murphy et al., 2004; van Driel et al., 2001); therefore, the current study findings seemed to come as no surprise. Similarly, Buehl and Fives (2009) pointed out the role of professional knowledge gained through sources, including publications and the world wide web, and the teaching experience as the most common sources of teachers' beliefs about teaching. In the Turkish context, Isikoglu, Basturk, and Karaca (2008), and Şahin, Işıksal, and Ertepınar (2010) confirmed the important role of teaching experience in the formation of teachers' general beliefs about teaching. Every change in the system might, indeed, challenge novice teachers; however, they learn how to balance their expectations and experiences as they spend more time in the teaching profession. In addition, the accumulation of teaching experiences over the years might help teachers develop a larger repertoire of professional knowledge and necessary pedagogical skills, which would be instrumental in adopting the changes in the curricula by employing different approaches and strategies (Isler & Cakiroglu, 2009).

The aforementioned factors also play a significant role in teachers' readiness for change, which is another considerable factor predicting teachers' attitudes towards the implementation of the constructivist curriculum change. Additionally, we noted that teachers' emotional readiness was deemed critical for a successful implementation of the constructivist curriculum change at the individual level. There might be a number of factors that might influence teachers' feelings towards this curriculum change. Consistent with the findings of the existing literature, uncertainty during change, teachers' insistence on their long-established instructional habits, and the lack of understanding about the change seem to boost the fear and uneasiness experienced by teachers and reduce their confidence, which in return, might increase their resistance to the changes brought by the new curricula (Altun & Şahin, 2009; Cerit, 2013; Du & Chaaban, 2020; Kosar Altinyelken, 2013). Indeed, teachers might prefer to stay in their comfort zones or preserve the status quo in their teaching rather than learn a new approach unless they are involved in decision-making processes about the change; and therefore, this might negatively impact their emotional readiness towards implementing the constructivist curriculum.

Second, regarding the *micro-system* of the curriculum change implementation that we built from Bronfenbrenner's ecological systems theory, our study revealed that teachers are surrounded by complex immediate environments that involve K-12 school curricula, students, parents, colleagues, and school administrators. These micro-systems influence teachers' self-efficacy beliefs for teaching, general beliefs about teaching, and readiness for change and make a significant impact on their attitudes towards the implementation of the constructivist curriculum change. By highlighting the interrelations among those micro-systems, such as parents, colleagues, and administrators, our findings also shed light into the meso-system of the curriculum change implementation, as explained further.

First, having a closer look at the findings at the micro-system level, it is remarkable to note that there is an apparent conflict between the intended curriculum change and its implementation, mainly due to some curriculum-related factors, such as the number of objectives, the intensity of the content, and the allocated time for them. Previous research also found that the curriculum's heavy structure and the time to cover all its elements seemed to have influenced teachers' belief systems in Türkiye, largely moving from the constructivist side to more traditional teaching beliefs (Haser & Star, 2009; Özgün-Koca & Şen, 2006). In our study, teachers frequently complained about how the written constructivist curriculum versus its actual implementation challenged their capability and made them unprepared for this change. That might be related to giving no space for teachers and ignoring their voice and autonomy in the curriculum design process, making them feel like technicians or implementers rather than decision-makers (Cobanoglu & Capa-Aydin, 2015). In this regard, the top-down imposition of the constructivist curriculum

change in Türkiye is often described as one of the main reasons for the failure of successful implementation (e.g., Yaşar & Sözbilir, 2019; Yildirim & Kasapoglu, 2015), which also confirms Fullan's (1991) proposition for the undeniable role of teacher beliefs in the implementation of top-down change practices. Additionally, the feasibility and flexibility issues in this centralized curriculum point to the same problem for teachers as they expressed that they usually became helpless and powerless to address students' needs and interests in their classes. Given these, it is reasonable that the top-down structure of the constructivist curriculum makes a negative impact on teacher belief systems.

Students, another element of the micro-system of the constructivist curriculum change, also seemed critical in shaping teachers' attitudes towards implementing the constructivist curriculum. The influence of students' changing profile, readiness and achievement levels, engagement, and motivation on teachers' self-efficacy beliefs for teaching might be explained by Bandura's (1997) triadic reciprocal causation model in the social learning theory. Accordingly, the model has a dynamic interaction of the individual, behavioral, and environmental factors, which attempts to describe how individuals' self-efficacy beliefs change. For the current study findings, teacher self-efficacy for teaching might be considered an individual factor that might influence or be influenced by environmental factors, including students' profiles, readiness and achievement levels, engagement, and motivation. That is, teachers would less often question their competency levels while implementing the constructivist curriculum unless students experience problems about the necessary prerequisite knowledge and skills or their achievement and motivation levels. Besides, the millennium children or Gen Z had different needs, interests, and expectations from the curriculum, especially with the immense advancement of technology, which might challenge teachers' capabilities and create tension and anxiety during the implementation process. Moreover, as for the beliefs about teaching, teachers would be more likely to tailor their instruction based on their students' academic knowledge, skills, motivation, and progress (e.g., Fleurette Nelson, 2017; Savasci, 2006).

Parents, who are a substantial element of the micro-system of the constructivist curriculum change, shaped teachers' belief systems and readiness to implement the constructivist curriculum as well. The literature highlights the need to raise parents' awareness of the constructivist curriculum change to deal with their lack of knowledge and interfering behaviors (e.g., Eraslan, 2013; Korkmaz, 2008; Kosar-Altinyelken, 2011; Yildirim & Kasapoglu, 2015). That sounds reasonable especially considering the dynamic interplays between parents, students, and teachers at the meso-system level. In parallel with our findings, parental involvement was underscored as a prominent factor in previous research (e.g., Savasci, 2006) in shaping teachers' instructional practices.

Schools, including their physical features, participants, and roles, constitute the final component of the micro-system of the constructivist curriculum change for the current study. First, the physical and technological infrastructure of schools seemed to put pressure on teachers while judging their capabilities and implementing the changed curriculum, and applying constructivist teaching pedagogies. The findings of several research also pointed out how large class sizes and lack of educational materials, sources, and technological infrastructure pose a threat to teachers' efforts to implement the constructivist curriculum successfully (e.g., Anılan & Sarıer, 2008; Bulut, 2007; Ersen & Yanık, 2008; Karadağ et al., 2008; Kosar Altinyelken, 2011; Yapıcı & Leblebiciler, 2007; Yaşar & Sözbilir, 2019). In our study, the gap between schools' physical and technical facilities and the implications of the intended curriculum change seemed to create distress and challenging teaching environments for teachers, debilitating their physiological and affective states, a common source of self-efficacy beliefs. Second, verbal persuasion and vicarious experiences, other sources of self-efficacy, seemed to influence teachers' capability judgments whenever they attempted to interact with the school administration or observe colleagues' behaviors towards the curriculum change. The research has also shown that colleagues play crucial roles in teachers' beliefs about teaching and their commitment or willingness to change the curriculum (Tobin et al., 1994).

Third, concerning the *exo-system* of curriculum change, the socio-cultural environment of the schools and mass media are the important factors especially influencing teachers' beliefs about teaching. As the curriculum change might be experienced differently depending on the school environment due to the lack of adequate resources in schools (Dönmez & Akar Vural, 2014; Gömleksiz & Öner, 2013), parents' involvement with their children's education (Bal & Doğanay, 2009; Yiğit et al., 2017), and the resulting challenges, the socio-cultural environment where the school is located might impact the effectiveness of the implemented curriculum change. Moreover, the negative representation of teachers in mass media such as devaluation, low status of the teaching profession and incidences of violence against teachers (Atmaca, 2020; Bayar & Bayar, 2022) similarly affect teachers' beliefs about teaching negatively. This might consequently influence their well-being and professional satisfaction (Bayar & Bayar, 2022), leading to a gap between the intended and the enacted curriculum within the ecology of education.

Lastly, our findings suggested that the *macro-system* of curriculum change ecology encompassed factors such as the structure and operational problems of the education system and of the Ministry of Education, the design and quality of nation-wide centrally designed and implemented professional development activities, the financial status of teachers, and the inadequacy of the pre-service teacher education policies and practices. Specifically, these structures were found to have a considerable impact on teachers' self-efficacy beliefs for teaching, general beliefs about teaching, and readiness for change; and therefore, were reported to influence their attitudes towards the implementation of the constructivist curriculum change.

In particular, at the macro-system level, we found that the observed pressure, the lack of psychological support from the ministry, the presence of a strict organizational hierarchy, changing nature of the system, and neglecting teachers' decisions had considerable impact on teachers' beliefs about teaching and self-efficacy beliefs for teaching in implementing the constructivist

curriculum. In line with the findings at the micro-system level, the top-down structure of the educational policy-making processes restricts teachers' endorsement of this change (Yildirim & Kasapoglu, 2015). That causes them to act as technician-teachers who possess the relevant knowledge and skills to implement the curriculum consistent with the demands of the authority but lack autonomy and reasoning and display a high level of fidelity to the curriculum and the top figures in making decisions during implementation (Yıldırım, 2011). On the contrary, professionals in shared control and distributed decision-making situations are more likely to make sense of the curriculum by being flexible in adapting and transforming their knowledge and skills to respond to the needs of the curriculum. As Jenkins (2020) argued, in top-down curriculum reforms, teachers might display passive agency, leading them to maintain their existing teaching practices, feel alienated from the teaching profession, and experience intense frustration (Carse, 2015). This might explain teachers' hesitations and potential questions about their capabilities and teaching beliefs in implementing the changed curriculum. Besides, the literature also underlines the hindering role of the system's constantly changing nature or instability concerning the curriculum and educational policy changes. In such conditions, teachers might expect to return to the old curriculum and implementation practices, which might also cause difficulties for teachers in internalizing the changes and adapting their instructional practices accordingly (Bümen, 2005). In addition to the top-down imposition and the instability of the changes in the educational system, the unclear explanation of such changes might lead teachers to criticize the curriculum in terms of its functionality and applicability (Altun & Şahin, 2009), diminishing their readiness towards implementing changed-oriented practices in the curriculum.

Concerning the macro-system of the ecology of constructivist curriculum change, second, the design and quality of the professional development activities developed and implemented by the MoNE seem to be incongruent with the essential characteristics of the change. That is, in parallel with the literature, the professional development activities were found insufficient and unsuitable for fulfilling teachers' desire to improve their knowledge, skills, and attitudes about the constructivist curriculum (e.g., Bulut, 2007; Buluş Kırıkkaya, 2009; Doğanay & Sarı, 2008; Yaşar Sözbilir, 2019). Teachers especially complained about the design and implementation of those activities since much emphasis was placed on the theoretical foundations, rather than providing teachers with adequate hands-on experiences and good practices. Additionally, the instructors' or trainers' competency levels were criticized. These findings are also evident in the literature (e.g., Altun & Şahin, 2009; Buluş Kırıkkaya, 2009), and they point to an important problem for teachers' self-efficacy beliefs. Teachers might have the opportunity to observe and model the instructors' knowledge, skills, and behaviors in those nation-wide trainings and make inferences by considering the context of their own students and classes. Yet, the aforementioned problems decrease the chance of observing and modeling effective practices; and therefore, diminish teachers' vicarious experiences, the second essential source of self-efficacy. Besides, as teachers hold beliefs about their teaching, learning, and students (Pajares, 1992), regardless of any change, those activities seemed to fall behind providing the true meaning and principles of the constructivist curriculum, which would shape the beliefs that teachers hold about teaching by sufficiently preparing them to embrace the basic principles of this curriculum change.

At the macro-system level, teachers' financial status has also influenced their belief systems and readiness for the curriculum change. As many teachers criticized the quality of professional development activities, they tended to seek alternative routes to advance their knowledge and skills towards the constructivist curriculum; however, teachers' salary or income levels seemed to prevent them from reaching the relevant sources. Indeed, the economic conditions of teachers concerning their salary are listed as one of the factors impacting the status of the teaching position (Ünsal, 2018). This might also affect teachers' productivity and the quality of their teaching. In Türkiye, the salary of Turkish teachers is below the OECD average (Arslan, 2017), which might challenge their living conditions and establish their priorities accordingly. Therefore, the shortfalls in fulfilling the tangible (e.g., instrumental and material) and intangible (e.g., knowledge and skills) needs towards implementing the constructivist curriculum might make them feel incompetent and unprepared for this change.

Lastly, teachers highlighted the shortcomings of the pre-service teacher education programs, another substantial component of the macro-system, in providing future teachers with the essential knowledge, skills, and attitudes for implementing the constructivist curriculum. The literature also stressed the role of pre-service teacher education programs in shaping pre-service teachers' beliefs concerning the curriculum (Çobanoğlu, 2015; Ogan-Bekiroglu & Akkoç, 2009; Uzuntiryaki et al., 2010; Toluk Uçar & Demirsoy, 2010). As pre-service teachers enter those programs with already existing beliefs about teaching, there might be inconsistencies between the curriculum requirements and teachers' classroom practices unless teacher education programs provide sufficient opportunities for teacher candidates to help them develop the essential knowledge, skills, and attitudes to implement the curricular changes successfully. In this regard, teacher education programs were criticized for drawing much attention to theory-driven courses rather than promoting pre-service teachers' skills and experiences in student-centered pedagogy. Similar to pre-service teacher education, teaching experiences also contribute to in-service teachers' mastery experiences, increasing their self-efficacy beliefs for teaching. Therefore, the emphasis placed on theory-driven courses rather than providing teacher candidates with more opportunities to transform the theory into practice would lessen their mastery (i.e., direct teaching experiences) and vicarious experiences (i.e., observing credible models' teaching) even during their initial teacher education and would create major problems when they start their professional careers. Since beginning teachers usually deal with several difficulties in their early years of teaching, such as seeking to develop their professional identity and maintaining their presence in the classroom despite the lack of support from academic mentors, their self-efficacy levels display a falling tendency

(Woolfolk Hoy & Burke-Spero, 2005). Therefore, pre-service teacher education programs might be a critical foundation for pre-service teachers to embrace the essential characteristics of the constructivist curriculum and implement it successfully.

CONCLUSION AND RECOMMENDATIONS

Effective and supportive ecological systems are likely to facilitate the implementation of the intended curriculum change process. Taken together, this study suggests how these systems (teacher-, micro-system-, meso-system-, exo-system, and macro-system-related factors) are intimately interrelated, and that omission of this holistic perspective is likely to result in an incomplete representation of the implementation of curriculum change. Accordingly, the findings of the study, first, may help policymakers and curriculum development experts be aware of potential factors influencing teachers' attitudes towards curriculum change in Türkiye and beyond. To that end, although the study acknowledges the influence of many stakeholders in the implementation of the curriculum change process, the findings, above all, suggest that teachers sit at the heart of the curriculum change process; and therefore, their attitudes and beliefs including self-efficacy beliefs for teaching, general beliefs about teaching, and readiness for change should not be neglected for the success of the change. This further implies that teachers should be encouraged to act as agents of change and their perspectives, suggestions, and feedback should be taken into consideration throughout the change process for continuous improvement as opposed to the view that positions teachers simply as the deliverers of a prescribed curriculum. However, there is a recent curriculum movement in Türkiye called the 2024 Education Model, which also reflects a top-down curriculum development practice. Only one week was given to curriculum stakeholders, including teachers, curriculum development experts, academics, parents, and citizens, to submit their suggestions and criticisms about the model. Thus, teachers might simply find it challenging to internalize recent changes and provide quality feedback, without their beliefs and readiness for change taken into consideration. Given that teachers' beliefs about teaching, self-efficacy for teaching, and readiness for change are essential for successful curriculum implementation, considerable attention should also be given to these elements when considering the ecology of curriculum change as they are essential for ensuring the sustainability of the intended changes. Moreover, based on the factors found at several levels of the ecology of curriculum change, policymakers and curriculum development experts may plan interventions to support teachers for a successful implementation of the intended change. More specifically, teachers might be provided with in-service trainings before and throughout the curriculum change implementation process to reduce the feelings of fear, anxiety, and uncertainty that every change brings to some extent. In so doing, such trainings should be designed in a way that comprises a synergistic blend of practice and theory so that teachers, in collaboration with school principals and other significant collaborators in the school climate, can develop both the knowledge and skills that are needed for the particular change, especially with the presence of direct modeling provided by the instructor. Future professional development programs must prioritize hands-on, practical training that features expert modeling and mentorship. In this regard, the findings of this study also point to the urgent need for pre-service teacher education programs to be enriched through more practice and school-based experiences so as to foster pre-service teachers' professional development and familiarity with the curriculum, as well as the roles expected from teachers and students. Moreover, given that curriculum implementation is always impacted by economic concerns and technological infrastructure, teachers and schools should be supported with the necessary learning resources and suitable infrastructure not only for the success but also the sustainability of the intended curricular changes.

Similarly, considering that parents are one of the most important stakeholders who often have power and strong views about what their children's education should achieve, trainings might also be offered to parents to raise their awareness about the new roles expected from learners and teachers in the curriculum. For example, parents should be engaged in workshops to better understand their evolving role in student learning according to the constructivist curriculum. Moreover, to help school principals, who play a critical role in managing the implementation of curriculum change processes at the school level, especially in the top-down hierarchical implementation structures, school principals might be provided with assistance and trainings about the nature and implications of the curricular changes as well as how to create a positive, cooperative, and supportive school climate for teachers to enact the intended change without fear of failure and bring it to life successfully.

The findings of the present study mainly elaborated on teacher-related factors and the factors related to the micro-system, meso-system, exo-system, and macro-system of the curriculum change in an effort to understand teachers' self-efficacy beliefs for teaching, general beliefs about teaching, and readiness for change. Given this, future research might further investigate the chrono-system of the ecology of curriculum change implementation and describe how settings and teachers' implementation of the constructivist curriculum evolved over time. Lastly, it is recommended that future studies should employ multiple sources of evidence, such as data from interviews, observation, and document analysis, to shed light into the actual implementation of the intended curriculum change, which might offer a more nuanced portrayal of the ecology of curriculum change implementation. While this study focuses on teachers, additional research could also incorporate perspectives of students, parents, school principals, and policymakers. This would provide a more comprehensive view of curriculum change, as these groups are key actors in the ecological system of curriculum change.

Declaration of Conflicting Interests

The authors declared no conflict of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has no unethical issues, and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers. The first author has made substantial contributions to the conceptualization, the research design, data collection, analysis and interpretation of the data, reporting the findings, and writing/editing/revising the manuscript. The second author has made substantial contributions to the conceptualization, the research design, data collection, analysis and interpretation of the data, reporting the findings, and writing/editing/revising the manuscript.

Ethics Committee Approval Information

The ethical committee approval was obtained for this research from TED University Human Subjects Ethics Committee with the decision numbered 2020/05, dated July 29, 2020.

This study is part of a larger research that was presented at the VIII. International Congress on Curriculum and Instruction (ICCI) on March 25-27, 2021.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 344-354
doi: 10.24106/kefdergi.1683474

|Research Article / Araştırma Makalesi|

The Effect of Algebra Teaching Supported by Thinking Class Materials on Problem Posing Attitudes of Secondary School Students[1]

Düşünen Sınıf Materyalleri İle Desteklenmiş Cebir Öğretiminin Ortaokul Öğrencilerinin Problem Kurmaya Yönelik Tutumlarına Etkisi

Elif Kara[2], Çiğdem Kılıç[3]

Keywords

1.Materials for Thinking Classroom

2. Algebra Teaching

3. Attitudes to Problem Posing

Anahtar Kelimeler

1.Düşünen Sınıf Materyalleri

2.Cebir Öğretimi

3.Problem Kurmaya Yönelik Tutum

Received/Başvuru Tarihi
14.10.2022

Accepted / Kabul Tarihi
19.02.2025

Abstract

Purpose: This study aims to examine the effect of algebra teaching supported by thinking classroom materials on middle school students' problem-posing attitudes.

Design/Methodology/Approach: The quasi-experimental method with a pretest-posttest control group was used in the study. The study participants, which was carried out for seven weeks in the first semester of the 2021-2022 academic year, consisted of 60 seventh-grade students attending a public middle school in the Pendik district of Istanbul. The Mathematical Problem Posing Attitude Scale (MPPAS) developed by Katrancı and Şengül (2019) to determine secondary school students' attitudes towards posing mathematical problems was used as a data collection tool in data collection in the research.

Findings: The MPPTS posttest scores applied to the experimental and control group students after the instruction showed a significant difference in favor of the experimental group. The positive effect of algebra teaching supported by thinking classroom materials applied to the experimental group on the problem-posing attitudes of secondary school students was observed.

Highlights: No study has been found that measures students' attitudes towards problem-posing in algebra teaching supported by thinking classroom materials. Considering that students' problem-posing attitudes are important, this study is thought to contribute to the literature.

Öz

Çalışmanın amacı: Bu çalışmanın amacı düşünen sınıf materyalleriyle desteklenmiş cebir öğretiminin ortaokul öğrencilerinin problem kurma tutumlarına etkisini incelemektir.

Materyal ve Yöntem: Çalışmada ön test- son test kontrol gruplu yarı deneysel yöntem kullanılmıştır. 2021-2022 eğitim öğretim yılının birinci döneminde yedi hafta boyunca gerçekleştirilen çalışmanın katılımcıları İstanbul ili Pendik ilçesinde bir devlet ortaokuluna devam eden 60 ortaokul yedinci sınıf öğrencisiden oluşturmaktadır. Araştırmada verilerin toplanmasında veri toplama aracı olarak Katrancı ve Şengül (2019)'ün ortaokul öğrencilerinin matematik problemi oluşturmaya yönelik tutumlarını tespit etmek için geliştirdiği Matematik Problemi Oluşturma Tutum Ölçeği (MPOTÖ) kullanılmıştır

Bulgular: Yapılan öğretimin ardından deney ve kontrol grubu öğrencilerine uygulanan MPOTÖ son test puanlarının deney grubu lehine anlamlı farklılaştığı sonucuna ulaşılmıştır. Deney grubuna uygulanan düşünen sınıf materyalleri desteklenmiş cebir öğretiminin ortaokul öğrencilerinin problem kurma tutumları üzerine olumlu etkisinin gözlemlendiği sonucu ortaya çıkmıştır.

Önemli Vurgular: Düşünen sınıf materyalleri ile desteklenmiş cebir öğretiminde öğrencilerin problem kurmaya yönelik tutumlarını ölçen çalışma çalışmaya rastlanmamıştır. Öğrencilerin problem kurma tutumlarının önemli olduğu düşünüldüğünde bu çalışmanın alan yazına katkı sağlayacağı düşünülmektedir.

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Citation/Alıntı: Kara, E., & Kılıç, Ç. (2025). The Effect of Algebra Teaching Supported by Thinking Class Materials on Problem Posing Attitudes of Secondary School Students, Kastamonu Education Journal, 33(2), 344-354. doi: 10.24106/kefdergi.1683474

INTRODUCTION

Problem-posing is an essential competency in the mathematics curriculum, distinct yet equally important as problem-solving. A review of the literature reveals that this mathematical activity has been defined in various ways by researchers, including terms such as "problem designing" or "problem-posing" (Cankoy & Darbaz, 2010; Kılıç, 2011; Ünveren-Bilgiç & Çaylan, 2018; Katrancı & Şengül, 2019). In the Middle School Mathematics Curriculum (2018), problem posing is a skill intended to be realized after the problem-solving steps (p. 27). The most common definition of problem-posing skill was made by Silver (1994) as creating new problems based on an existing mathematical situation or posing a new problem in the problem-solving process.

Problem posing is a potent mathematical activity that can integrate mathematical knowledge with existing knowledge (Kılıç, 2017). It includes many cognitive competencies such as problem posing, solving daily life problems and mathematical situations by formulating, choosing appropriate approaches to a mathematical situation, and learning by associating different mathematical subjects (Abu-Elwan, 1999). Problem posing, expressed as a mathematical competence and used as an assessment tool that reveals students' knowledge, is also an approach that reveals the practical and important aspects of students' mathematical thinking or their learning in which they are not competent. While giving mathematical information to the learners in a mathematics course, a general framework is tried to be followed. At the same time, it aims to develop the mathematical thoughts of the learners by using different approaches (Alkan & Bukova Güzel, 2005).

The studies on problem posing in the literature show that there are different problem-posing frameworks (English, 1997; Brown & Walter, 1993; Christou et al., 2005; Stoyanova & Ellerton, 1996; Stoyanova, 2003; Kılıç, 2013). Christou et al. (2005) examined problem-posing situations with cognitive processes and divided them into four categories.

- Editing quantitative information: Students are asked to pose a problem using any given picture, story, or information without limitations.
- Selecting quantitative information: The student is expected to pose a problem based on a given answer.
- Comprehending quantitative information: Students are asked to pose problems using mathematical operations or algebraic expressions.
- Translating quantitative information: The student is given tables, diagrams, or graphs and asked to create appropriate problems.

Stoyanova and Ellerton (1996) analyzed problem posing in three categories. These categories were analyzed: free problem posing, semi-structured problem posing, and structured problem posing. No restrictions can be placed on creating free problems; students are expected to pose problems involving an actual situation (Stoyanova, 2003; Kılıç, 2013). Appropriately, for this situation, an example could be given where you pose a complex math problem whose general instruction is appropriate for a real-life situation. In semi-structured problem posing, students are asked to pose a problem based on an existing situation using algebraic expressions, a figure, or a picture of a particular operation path or result (Stoyanova, 2003). Flexibility and limitations are recognized simultaneously in such activities (Kılıç, 2013). The activity "Construct a problem that can be solved by the operation (42+18) ÷ 6 = 10" can be an example of semi-structured problem posing. Structured problem-posing situations are characterized as new scenarios when a well-defined problem or situation is provided. Rephrasing a problem based on its solution and presenting it in various information formats are typical examples of this concept (Stoyanova, 2003).

Kılıç (2013) studied the problem-posing strategies of pre-service teachers. She determined that they can emerge as original strategies or common problem-posing strategies and classified them based on the problem-posing situations of Stoyanova and Ellerton (1996) and the problem-posing model of Christou et al. (2005).

The results of studies on problem posing indicate that one of the primary difficulties students face when dealing with algebraic expressions is their incomplete understanding of algebraic concepts. Research has shown that issues related to learning algebra, including misconceptions and challenges in solving and creating problems, persist (Şimşek & Soylu, 2018; Yağız, 2019; Türkmen, 2019). One of the most important reasons for these problems may be that algebra is an abstract concept not concretized enough to be adapted to daily life situations. It is seen that some mistakes made in algebra teaching cause students to have difficulties in making sense of algebraic concepts. Problem-posing is used to overcome these difficulties and analyze the difficulties students encounter while making sense of algebraic concepts (Cañadas, Molina, & del Río, 2018). It is thought that the attitude towards problem posing will determine the factors that influence success in mathematics, and developing a positive attitude will turn the students into good problem solvers. Solving and posing mathematical problems and raising students with positive mathematical attitudes are among the issues the national education system and teachers should work on by giving importance to (Katrancı & Şengül, 2019). When the literature is examined, it is seen that many studies include different methods in the field of equality and equation sub-learning of the algebra learning field (Özbey & Koparan, 2020; Karakaş, 2019; Aygün, 2019; Türkmen,2019; Arabacı,2016; Akarsu,2013; Takir, 2011; Palabıyık, 2010; Öner, 2009) but it has been reached that teaching activities based on direct thinking classroom materials for teaching algebra have not been developed, and students' problem posing performance and especially problem posing attitudes have not been examined with these activities. It is seen that these studies aim to embody the abstract structure of algebra. Not using appropriate methods and techniques in algebra teaching makes it difficult for learners to make sense of algebra concepts. It causes learning by rote by making the concepts contain algebra rules. This situation prevents

students from thinking algebraically and negatively affects their ability to solve and construct verbal algebraic problems. These disruptions in the learning process cause students to develop negative thoughts about problem-posing and negatively affect their problem-posing attitudes. It is stated that secondary school students' problem-posing success is positively related to their attitudes towards mathematical problem-posing at a low level (Katrancı, 2022).

It is seen that most students have negative attitudes towards mathematics, which is perceived as an entirely abstract field by students. It can be said that students who can solve a problem they encounter in real life when they encounter the same problem in the name of mathematics course, they become afraid and withdrawn and exhibit negative attitudes (Özgen, Aydın, Dinç, Şeker, & Alkan, 2019). Bonotto (2013) states that if students are given the task of problem-solving and problem-posing related to the subjects they are interested in in the classroom environment, students' problem-solving and posing skills will develop positively. For this reason, it is thought that by using problem-posing activities involving daily life situations in the learning environment in the study, students will concretize algebraic concepts containing abstract expressions to ensure permanent learning and prevent misconceptions in teaching algebraic expressions. Enriching learning environments and designing them to encourage learners to consider abstract concepts are crucial in teaching algebra. In this context, the use of effective class materials will enhance the teaching of algebra. Additionally, during problem-posing activities, it is important to acknowledge that, along with cognitive factors, affective factors such as attitudes also play a significant role.

The researchers presented various suggestions for an ideal classroom environment that supports thinking, and appropriate methods were created. These methods are divided into the ideal learning environment and the classroom environment that supports thinking (Doğanay & Sarı, 2012). Reflective classrooms aim to create willing and engaged students who think about any task rather than finding interesting tasks for students to think about (Lilhedajl, 2022).

Lilhedajl (2022) created a thinking classroom framework to make students think and increase the thinking process's permanence. This framework, which includes a sequential order, has been called the thinking classes' generation framework. This framework, created by Lilhedajl (2022), is structured sequentially. According to the stages of the framework for creating thinking classes:

In the first stage, all three applications should be applied simultaneously, not sequentially. Randomly dividing the students into groups increases their interest and excitement about the lessons and positively affects their attendance. In discussion groups, there is a flow of information between students, and students can easily express their thoughts.

The second stage includes teaching practices, which is very important for laying the foundations for the third stage. At this stage, students are involved in the course flow and can practice what they have learned by performing their learning.

In the third stage, students are ready and willing to think about everything, including the teaching content, during the course flow. At this stage, a culture of thinking begins in the classroom. Through hints, students are provided to think, and information is conveyed, and they are reinforced. Note-taking for individualizing and concretizing the information learned in student groups also occurs at this stage.

The fourth stage is the final stage, during which all evaluations occur. All reflective classroom practices end at the fourth stage because teaching practices have been in flux up to this point, and assessment reflects teacher practice.

Since learners are actively involved in their learning processes by posing problems, teachers must design appropriate in-class learning-teaching processes in order to gain problem-posing ability (Aydoğdu-İskenderoğlu & Güneş, 2016; Hartmann, Krawitz & Schukajlow, 2021). In this context, when the studies conducted with students in the literature are examined within the framework of problem-posing in the field of algebra (Dinç, 2018; Dur, 2020; Kaya, 2020), it is seen that studies that support problem-posing by embodying algebra teaching by concretizing it with daily life have positive contributions to algebra teaching and problem posing. This research aims to create a thinking-friendly classroom environment, provide permanent learning, and help problem posing by concretizing the concepts of 7th-grade algebra teaching with thinking class materials. For this reason, it is essential to design and create learning environments in which various teaching methods and techniques are used for different sensory organs, and learners take an active role in the center to realize permanent learning.

It is predicted that mathematics will be learned more effectively with the problem-solving and creation environment created by constructing the teaching environment supported by thinking classroom materials with concrete materials containing visual elements and activities, using constructive discussions with collaborative heterogeneous groups that enable students to understand their environment and associate it with real life by mathematizing it. In addition, open-ended problems aimed at advanced thinking will significantly impact mathematical reasoning and thinking power, and learners' attitudes towards posing mathematical problems will also be positively affected by the fun and different methods used. In this sense, the study will contribute to the problem posed by the literature.

The research aimed to answer the following questions:

1. Is there a significant difference in the attitudes towards posing mathematical problems between students in the experimental group, who participated in algebra teaching supported by thinking classroom materials, and those in the control group?

2. Is there a significant difference in the scores of the experimental group students on the math problem-posing attitude scale between the pre-test and post-test?

3. Is there a significant difference in the scores of the control group students on the math problem-posing attitude scale between the pre-test and post-test?

METHODS

In the study, a quasi-experimental design with a pretest-posttest control group was used since it was desired to investigate the effect of algebra teaching supported by thinking class materials on the problem-posing attitudes of middle school seventh-grade students. Quasi-experimental designs are defined as a preferred design in research situations where random sampling cannot be done while adhering to fundamental experimental design principles, which is carried out to determine cause-effect relationships (Büyüköztürk, Kılıç-Çakmak, Akgün, Karadeniz, & Demirel, 2018; Creswell, 2007). Since the research examines the effect of two different methods on problem-solving attitudes in teaching algebra, the aim is to evaluate the new method according to the current method (Gliner, Morgan, & Harmon, 2003). The classroom environment is created using classroom materials that consider the independent variables of the research and in-class activities carried out with the traditional method. The dependent variables of the research are the attitude towards problem posing in the field of learning algebra.

Research Group

The research study group includes seventh-grade students attending a public school in the Pendik district of Istanbul during the first semester of the 2021-2022 academic year. Since it is the institution where the researcher works, the convenient sampling method was preferred among the non-random sampling methods while determining this school. In this method, compliance with the purpose of the researcher is observed (Büyüköztürk et al., 2018). The student groups in the study were formed randomly. Data were collected from 30 students in the experimental group and 30 students in the control group. The research involved 60 seventh-grade students, consisting of 36 girls and 24 boys, aged between 11 and 13 years. Considering the number of students is equal, one class experimental group was determined as one class control group. Students in B (experimental group) and A (control group) branches participated in the study. Before the experiment, both groups were pre-tested, and the results were compared. The results were equal.

Data collection tools

The study used the mathematical problem-posing attitude scale (MPPAS) prepared by Katrancı and Şengül (2019) to examine students' attitudes toward problem-posing. This study used the Mathematics Problem Posing Attitude Scale (MPPAS), developed by Katrancı and Şengül (2019), to determine middle school students' attitudes toward posing mathematical problems. While creating the scale questions, attention was paid to the relationship between cognitive, affective, and behavioral characteristics and attitude. The scale, which consisted of 68 items at the beginning of the study, was reduced to 37 items due to the factor analysis. There are 13 positive and 24 negative items on the scale. Positive items 1, 5, 10, 14, 18, 21, 24, 27, 29, 31, 32, 34 and 37 of the scale items; 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 15, 16, 17, 19,20, 22, 23, 25, 26, 28, 30, 33, 35 and 36 have negative items. Forms. The scale was prepared in a 5-point Likert type as "I strongly disagree (1), I do not agree (2), I neither agree nor disagree (3), I agree (4), and I completely agree (5)".

MPPAS consists of three dimensions: "Dislike," "Self-confidence" and "Self-confidence". 2, 4, 11, 12, 13, 15, 16, 17, 19, 20, 22, 23, 25 and 26 on the scale; items containing the dislike factor; Items including 3, 6, 7, 8, 9, 28, 30, 33, 35 and 36 insignificance factors; 1, 5, 10, 14, 18, 21, 24, 27, 29, 31, 32, 34 and 37 were determined as items containing self-confidence factor. Cronbach Alpha value for each sub-dimension of the scale, respectively. 90, .85, .81; for the whole scale. It was measured as 91. In the factor analysis for 37 items of the scale, It was found that the first factor contributed to the common variance of 16.809%, the second factor 12.403%, and the third factor around 11.190%. The total contribution of the three factors of the scale was determined as 40,402%. As a result of the confirmatory factor analysis performed in the final version of MPPAS, the ratio of $XX2/ssss$ was found to be 2.71 on the scale.

Data collection procedure

The study was designed to last four weeks, encompassing twenty course hours focused on the algebra curriculum for 7th grade. Its aim was to assess the impact of algebra instruction supported by thinking class materials on students' attitudes towards problem posing. To facilitate this, a learning environment and materials were specifically prepared for the experimental group. In contrast, the control group was provided with a learning environment that utilized worksheets.

In the research, teaching the equality and equation gains of the 7th-grade algebra subject in the experimental group was carried out with activities prepared according to thinking classroom material (TCM). These activities were created by examining the achievement tests, skill-based questions, and PISA questions published by the Ministry of National Education.

The prepared lesson plans were examined by two different mathematics teachers and an academician who is an expert in mathematics education and arranged for use in the study. Expert opinion was sought for the six worksheets prepared for use in the experimental group. Necessary arrangements were made to ensure the linguistic compatibility of the activities. In addition,

within the framework of the opinion received from the experts that the problems appropriate for real-life situations given in the activities should appeal to every student, the problems were revised, and the activity papers were ready for application.

In the control group, lesson activities were prepared using middle school mathematics textbooks (MEB, 2020) prepared by the Ministry of Education within the framework of the mathematics curriculum. The expert opinion made necessary corrections. The linguistic compatibility of the activities prepared for the control group was checked, and necessary arrangements were made.

In order to determine whether there is a statistically significant difference between the experimental and control groups in terms of their attitudes towards problem posing, the mathematics problem posing attitude scale (MPPAS) was applied to the students in both groups as a pre-test before the application was made. After the pre-test applications were carried out for both groups and the equivalence between the groups was achieved, the 4-week period of the experiment began. During 20 lesson hours, teaching the equality and equation sub-learning domain achievements was carried out in the classroom environment supported by the researcher's thinking class materials to the experimental group and by applying activity papers containing the traditional teaching method to the control group.

Learning environments were organized by considering the stages of creating a thinking class in the environment created while the lesson was being taught with the thinking class materials. After all the students answered the activity papers from the beginning of the lesson, the researcher asked randomly selected student groups to read the answers given by the students to the questions in the activity and to solve these questions on the board. In response to the answers given by the students, the researcher provided feedback and corrections where necessary. At the end of the study, the researcher resolved the answers to the other exercises in the activity sheets and the solutions to the problems, and the lessons ended.

Table 1. Study Schedule for Experimental and Control Groups

1. Week (1 lesson + 1 lesson hour)	"PPT" and "MPPAS" were applied to two groups as a pretest.
2. Week (5 lesson hours)	Teaching was carried out to understand the principle of preservation of equality and in-class activities were carried out.
3. Week (5 lesson hours)	The concept of a first-order equation with one unknown and activities aimed at establishing a first-order equation with an unknown in accordance with given real-life situations were taught.
4. Week (5 lesson hours)	Practice exercises were conducted to solve first-order equations with one unknown.
5. Week (5 lesson hours)	In-class exercises and activities were carried out to solve problems that required establishing a first-order equation with one unknown.
6. Week (5 lesson hours)	In-class and activities were carried out to pose problems that required establishing a first-order equation with one unknown.
7. Week (1 lesson hour + 5 lesson hours)	"PPT" and "MPPAS" were applied to two groups as a posttest.

Planning Lessons in a Thinking Classroom Environment and Activity Sheets for Algebra Teaching Supported by Thinking Classroom Materials

Learning environments have been arranged by considering the stages of creating a thinking class in the environment created while teaching with thinking classroom materials. After all, students had answered the activity sheets from the class time when the study started. The researcher randomly selected student groups to read the answers given by the students to the questions in the activity and to solve these questions on the board. In response to the students' answers, the researcher provided feedback and corrections where necessary. At the end of the study, the answers to the other exercises and the solutions to the problems in the activity sheets were solved by the researcher, and the lessons ended.

The Anticipation Phase: In this stage, students create their learning goals by becoming aware of their existing knowledge within the framework of a conversational conversation. A discussion environment is created to create and understand new information using old information. The first exercise in the activities prepared for the course represents this stage. Figure 1 below shows a section from the activity sheet used in the course. The dialogue in the activity was read and discussed with the students, and the lesson continued.

ETKINLIK-3

DENKLEM MI, KURALIM BAKALIM?

KAZANIM: Birinci dereceden bir bilinmeyenli denklemi tanır ve verilen gerçek hayat durumlarına uygun birinci dereceden bir bilinmeyenli denklem kurar.

Süre: 5 ders saat

3x+6=12

Iki iyi arkadaş olan Ayça ve Kerem "3x+6=12" hakkında konuşurlar.

Ayça: 3x+6 cebirsel bir ifadedir. Içinde bilinmeyen ve bir de toplama işlemi var.

Kerem: "=" sembolü de var. Hatta =12. Aklıma terazi örneği geldi Ayça.

Ayça: Evet terazinin bir kefesi 3x+6, diğer kefesi de 12.

Kerem: Bu ifadenin bir adı vardı neydi?

Ayça: Neydi hadi hatırla bakalım. Içinde bilinmeyen bulunan ve bilinmeyenin bazı değerleri için doğru olan ifadelere ne denildiğini öğrenmiştik?

Kerem: Buldum. Denklem olarak öğrenmiştik.

Figure 1. Experimental Group work Sheet Sample

The Building Knowledge phase: This is the stage where students actively discuss, ask questions, try to make sense of the material, share their thoughts, and make inferences during the learning process. The second and third exercises in the prepared lesson plans include this stage. Figure 2 below shows a section from the activity sheet used in the course. The dialogue in the activity was read and discussed with the students, and the lesson continue

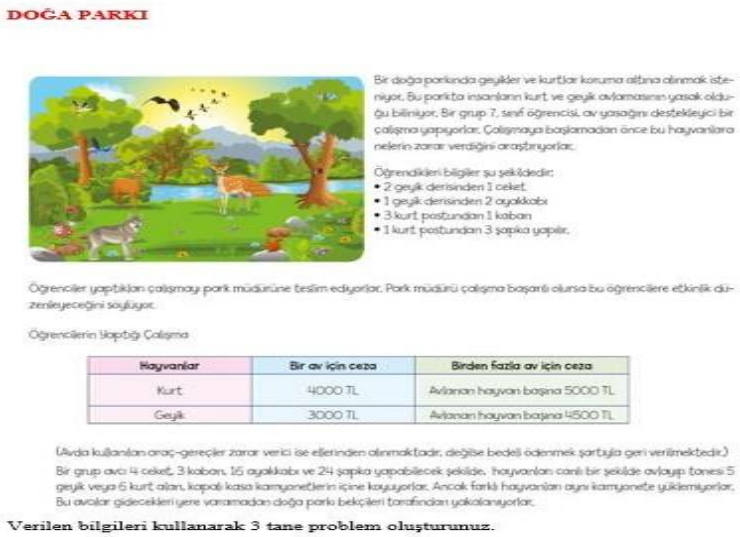
ALIŞTIRMA 2:

Can ile Han'ın yaşları toplamı 50 dir. 5 yıl sonra Han'ın yaşı Can'ın yaşının iki katı olacağına göre Han'ın şimdiki yaşını bulmamızı sağlayan denklemi yazınız.

ÇÖZÜM:

Figure 2. Experimental Group Work Sheet Sample

The Consolidation Phase: This phase is included in the activities at the end of the lesson. As a guide, the teacher completes the lesson by asking students to think about what they have learned, make sense of the information, and establish the relationship between their old learning and new learning. Figure 3 below shows a section from the activity sheet used in the course. The dialogue in the activity was read and discussed with the students, and the lesson continued.



DOĞA PARKI

Bir doğa parkında geyikler ve kurtlar koruma altına alınmak isteniyor. Bu parkta insanların kurt ve geyik avlamasının yasak olduğu biliniyor. Bir grup 7. sınıf öğrencisi, av yasağını destekleyici bir çalışma yapıyorlar. Çalışmaya başlamadan önce bu hayvanlara nelerin zarar verdiğini araştırıyorlar.

Öğrendikleri bilgiler şu şekildedir:
- 2 geyik derisinden 1 ceket
- 1 geyik derisinden 2 ayakkabı
- 3 kurt postundan 1 kaban
- 1 kurt postundan 3 şapka yapılır.

Öğrenciler yaptıkları çalışmayı park müdürüne teslim ediyorlar. Park müdürü çalışma başarılı olursa bu öğrencilere etkinlik düzenleyeceğini söylüyor.

Öğrencilerin Hazırladığı Çalışma

Hayvanlar	Bir av için ceza	Birden fazla av için ceza
Kurt	4000 TL	Avlanan hayvan başına 5000 TL
Geyik	3000 TL	Avlanan hayvan başına 4500 TL

(Avda kullanılan araç-gereçler zarar verici ise eşlerinden alınmaktadır, değilse bedeli ödenmek şartıyla geri verilmektedir.)

Bir grup avcı 4 ceket, 3 kaban, 16 ayakkabı ve 24 şapka yapabilecek şekilde, hayvanları canlı bir şekilde avlayıp tanesi 5 geyik veya 6 kurt alan, kapalı kasa kamyonetlerin içine koyuyorlar. Ancak farklı hayvanları aynı kamyonete yüklemiyorlar. Bu avcılar gideceklerı yere varamadan doğa parkı bekçileri tarafından yakalanıyorlar.

Verilen bilgileri kullanarak 3 tane problem oluşturunuz.

Figure 3. Experimental Group Work Sheet Sample

Data analysis

In order to analyze the data for the attitude scale of posing a mathematical problem, the total scores of the experimental group and control group were calculated and their normal distribution was examined. When the descriptive statistics were examined for the control of normality, it was seen that the kurtosis and skewness coefficients were between -1 and +1. The fact that these values are between -1 and +1 supports the normal distribution of the data (Büyüköztürk, 2019). It was observed that the MPPAS pretest-posttest scores of the experimental group and the control group showed a normal distribution (p>0.05). Therefore, it was deemed necessary to use samples t-test independent of parametric tests for the experimental group and control group in the analyzes for MPPAS. "Eta Square Effect Size" values were calculated and presented in the findings in order to determine the activity level of the groups with different independent samples t-test values. Independent samples t test Eta Square Value (η2)

$$\eta^2 = \frac{t^2}{t^2 + (N_1 + N_2 - 2)}$$

calculation formula; (Büyüköztürk, 2019).

In addition, the dependent samples t-test, one of the parametric tests, was used in the in-group analysis of the MPPAS pretest-posttest scores of the experimental group and the MPPAS pretest-posttest scores of the control group.

FINDINGS

In this segment of the research, we investigated the impact of problem-posing activities in algebra instruction, supported by thinking class materials, on the problem-posing attitudes of 7th-grade students. We assessed whether there was a statistically significant difference in the total scores from the Mathematical Problem-Posing Attitude Scale (MPPAS) before and after the intervention for both the experimental and control groups. We utilized a dependent samples t-test to analyze the scores within the experimental group and a separate independent samples t-test to compare the experimental and control groups. The results of these tests are provided in Table 2.

Table 2. Experimental and Control Groups MPPAS Pre-Test Scores t-Test Results

GROUP	N	X̄	S	t	sd	P
Control group	30	132,761	19,391	0,992	58	0,325
Experimental group	30	133,000	21,472			

When Table 2 was examined, it was concluded that there was no significant difference between the control group and the experimental group in the pre-test MPPAS scores before the application [t(58) = 0.992; p> 0.05]. Before the application, it was concluded that the scores of the control and experimental groups' attitudes toward posing a mathematical problem were equal.

Table 3. t-Test Results of the Experimental Group MPPAS Pre-Test Post-Test Scores

Group	X̄	N	S	sd	t	p
Ötop	138,000	30	21,472	29	3,093	0,013
Stop	118,200	30	22,561			

When Table 3 is examined, it is concluded that there is a significant increase between the mean scores of the students in the experimental group in the MPPAS pre-test (Eutop) and post-test (Stop) [t(29)=3,093; p<0.05). It has been concluded that "algebra teaching supported by thinking classroom materials" carried out with the students in the experimental group is an effective method in increasing students' attitudes towards posing mathematical problems.

Table 4. t-Test Results of the Control Group MPPAS Pre-Test Post-Test Scores

GROUP	X̄	N	S	sd	t	p
Ötop	132,7667	30	19,391	29	4,613	0,091
Stop	111,7667	30	16,093			

When Table 4 was examined, it was concluded that there was no significant increase in the mean scores of the students participating in the control group in the MPPAÖ pre-test (Ötop) and post-test (Stop) [t(29)= 4.613; p>0.05]. By comparing the

students' pre-research and post-research achievement scores, it was examined whether there was a change in the students' attitudes toward posing a mathematical problem. The algebra teaching studies conducted with the students in the control group found that it did not affect their attitudes toward posing a mathematical problem.

At the end of the application, the scores of the two groups from the MPPAÖ posttest were examined to determine whether there was a significant difference between the attitude scores of the control group and the experimental group students towards posing a mathematical problem. The obtained data were analyzed using the independent groups t-test, and the findings are given in Table 5.

Table 5. Experimental and Control Groups MPPAS Post-Test Evaluation Results

GROUP	N	X̄	S	t	sd	P
Control group	30	133,761	16,093	1,274	58	0,021
Experimental group	30	138,202	22,561			

DISCUSSION

When the literature is examined, it is seen that problem-posing activities positively affect students' beliefs, attitudes, skills, and self-efficacy toward mathematics (Özgen & Bayram, 2020; Katrancı &Şengül, 2019; Adal &Yavuz, 2017; Silver, 1994). Since learners are actively involved in their learning processes by posing problems, teachers need to design appropriate in-class learning-teaching processes to gain problem-posing ability (Aydoğdu İskenderoğlu & Güneş, 2016; Hartmann, Krawitz, & Schukajlow, 2021). In this context, when the studies conducted with students in the field of algebra are examined within the framework of problem posing in the field (Dinç, 2018; Dur, 2020; Kaya, 2020), it is seen that studies that support problem-posing by concretizing algebra teaching and associating it with daily life have positive contributions to algebra teaching and problem posing.

This study aimed to create a thinking-friendly classroom environment and provide permanent learning by concretizing the concepts of 7th-grade algebra teaching with thinking classroom materials and to help with problem posing. For this reason, it is essential to design and create learning environments where various teaching methods and techniques for different sense organs are used, and learners actively take a role in the center for permanent learning. It is predicted that mathematics will be learned more effectively with the problem-solving and creation environment formed by structuring the teaching environment supported by thinking classroom materials with concrete materials containing visual elements and activities, enabling students to understand their environment and associate it with real life by mathematicizing it, and constructive discussions with collaborative heterogeneous groups that enable peer learning. In addition, open-ended problems that aim to develop advanced thinking will significantly affect mathematical reasoning and thinking power. The fun and different methods will positively affect learners' attitudes towards posing mathematical problems. In this sense, the study will contribute to the literature on problem posing.

In order to examine the effect of algebra teaching supported by thinking class materials on middle school students' attitudes towards problem posing in the study, MPPAS was applied to the experimental and control group students as a pre-test and post-test. Before the application, it was observed that the attitude scores of the experimental and control groups toward posing a mathematical problem were equal. The problem is that the attitudes of both groups are at the same level. After the teaching, it was concluded that the MPPAS post-test scores applied to the experimental and control group students differed significantly in favor of the experimental group. It was concluded that the positive effect of algebra teaching, supported by the thinking class materials applied to the experimental group, on secondary school students' attitudes towards problem posing was observed. In her study with secondary school students, Katrancı (2022) showed that students' attitudes towards problem posing were effective in their success in problem posing.

Although there is no study examining the effect of algebra teaching supported by thinking classroom materials on the problem-posing attitudes of secondary school students, it is seen that there are studies (Katrancı & Şengül, 2019) examining the relationship between students' problem-posing attitudes, their problem posing performance, and their attitudes towards problem-solving and mathematics. Katrancı and Şengül (2019), in their study aiming to examine the relationships between middle school students' attitudes towards posing mathematical problems, their attitudes towards solving mathematical problems, and their attitudes towards mathematics, determined that the attitudes of middle school students towards posing, solving and solving mathematical problems and mathematics are in a positive sense and at a high level. When these results are examined, it is seen that there is a high level of relationship between students' attitudes towards creating and solving mathematical problems and mathematics.

In the studies, it is seen that the attitude toward problem posing is important in the self-efficacy perceptions of the students (Görgün, 2020) and the attitude towards mathematics (Ada, Demir & Öztürk, 2020). Görgün (2020) concluded that the problem-posing attitudes of the students are at a moderate level. In his study, he examined the perceptions of mathematics self-efficacy of secondary school students and their attitudes toward posing mathematical problems. Ada, Demir, and Öztürk (2020) concluded that sixth-grade students developed a positive attitude by breaking the prejudice they formed against mathematics while posing problems.

CONCLUSION AND RECOMMENDATIONS

Problem-posing performance and problem-posing attitude are related concepts in mathematics teaching. It was found that the problem-posing attitudes of students with high problem-posing performance were positively affected. Students who can pose problems develop self-confidence towards mathematics, and their anxiety during the learning process of mathematics is reflected in their attitudes toward the lesson. Thus, the problem-posing attitudes of the students who are more interested in the mathematics lesson are also positively affected. The process of forming an attitude through experiences can be included in the teaching activities in which the changes are observed by observing the learners in their learning environments. It is thought that the attitudes towards mathematics and posing mathematical problems can be changed positively with learning and teaching environments that support students' thinking, course contents that enable students' cognitive and affective processes to be effective, and course contents that offer the chance to learn by doing and experiencing.

Suggestions

● This research was designed and implemented at the seventh-grade level. A similar study can be conducted with students at various grade levels.

● The effect of algebra teaching supported by thinking classroom materials on students' affective skills, such as problem-solving and constructing self-efficacy, can be examined.

● The learning environment and activities can be prepared with reflective classroom materials to demonstrate problem-posing performance for different mathematics subjects.

● The effect of algebra teaching supported by thinking class materials using different problem-posing approaches on middle school students' problem-posing attitudes can be investigated.

● It may be suggested to investigate the effect of similar teaching materials to be prepared according to thinking class materials on larger sample groups or at different grade levels.

Declaration of Conflicting Interests

The author(s) declare that there are no potential conflicts of interest related to the research, authorship, or publication of this article.

Statements of publication ethics

We affirm that this study adheres to ethical standards and that all research and publication ethics have been meticulously followed.

Examples of author contribution statements

E.K. and Ç.K conceived of the presented idea. E.K. developed the theory and performed the computations. E.K. and Ç.K. verified the analytical methods. Ç.K. encouraged E.K. to investigate problem posing and supervised the findings of this work. All authors discussed the results and contributed to the final manuscript.

Researchers' contribution rate

The study was conducted and reported through equal collaboration among the researchers.

Ethics Committee Approval Information

This research was carried out with the approval of the Istanbul Medeniyet University Educational Sciences Ethics Committee. The approval decision was issued on December 7, 2020, with the reference number 2020/04-10.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 355-371
doi: 10.24106/kefdergi.1683483

| Research Article / Araştırma Makalesi |

Development of a Science Skill-Based Questions Achievement Test on Sound and Its Properties

Ses ve Özellikleri Konusunda Bilimsel Beceri Temelli Başarı Testi Geliştirilmesi

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Keywords
1.Skill-Based
2.Achievement test
3.Sound
4.Science education

Anahtar Kelimeler
1.Beceri temelli
2.Başarı testi
3.Ses
4.Fen eğitimi

Received/Başvuru Tarihi
13.11.2024

Accepted / Kabul Tarihi
14.04.2025

Abstract

Purpose: This study aimed to develop a skills-based achievement test for the learning outcomes of the subject of "Sound and Its Properties" in the newly implemented science curriculum.

Design: This research used a survey design as a skill-based test development study. The skill-based achievement test developed per the purpose of the study was applied to 375 6th-grade students, and the results were analyzed using the TestAn package program.

Findings: An achievement test consisting of 27 multiple-choice descriptive questions was developed within the scope of this study by examining PISA (Program for International Student Assessment), TIMSS (Trends in International Mathematics and Science Study), various achievement tests, resources, and previous studies in order to develop a test consisting of skill-based questions for the new science curriculum. It was determined that 23 of the 28 items in total had an item discrimination index of 0.40 and above; 4 items were between 0.30-0.39. One item, Question 27, was between 0.20-0.29 and removed from the test. The item analysis showed difficulty index values ranging from 0.28 to 0.72. The reliability coefficient of the skill-based achievement test was 0.80.

Highlights: This achievement test is particularly valuable for science teachers preparing students for the LGS (Turkish High School Entrance Exam), as it enables assessing their students' current proficiency levels.

Öz

Çalışmanın amacı: Güncellenen ortaokul fen bilimleri dersi öğretim programı yönelik olarak ses ve özellikleri konusuna uygun beceri temelli sorulardan oluşan akademik başarı testi geliştirmektedir.

Materyal ve Yöntem: Araştırmada beceri temelli test geliştirme çalışması olarak tarama deseni kullanılmıştır. Çalışmanın amacına uygun olarak geliştirilen beceri temelli başarı testi 375 6. sınıf öğrencisine uygulanmış ve sonuçlar TestAn paket programı kullanılarak analiz edilmiştir.

Bulgular: Çalışmada yeni fen bilimleri öğretim programına yönelik beceri temelli sorulardan oluşan bir başarı testi geliştirmek amacıyla PISA, TIMSS, başarı testleri, kaynaklar ve önceki çalışmalar incelenerek 27 adet çoktan seçmeli betimsel başarı testi geliştirilmiştir. Toplam 28 maddenin 23'ünün madde ayırt edicilik indeksinin 0,40 ve üzerinde, 4 maddenin 0,30-0,39 arasında, 1 maddenin ise 0,20-0,29 arasında olduğu belirlenmiştir. 0,20-0,29 arasında olan 27. soru testten çıkarılmıştır. Madde analizi, 0,28 ile 0,72 arasında değişen güçlük indeksi değerleri göstermiştir. Beceri temelli başarı testinin güvenirlik katsayısı 0,80'dir.

Önemli Vurgular: Bu başarı testi özellikle LGS'ye öğrenci hazırlayan fen bilimleri öğretmenleri tarafından öğrencilerinin mevcut durumlarını değerlendirmek için kullanılabilir.

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Citation/Alıntı: Şahin, H. N., Ersoy, E., & Ergun, M. (2025). Development of a Science Skill-Based Questions Achievement Test on Sound and Its Properties, *Kastamonu Education Journal, 33*(2), 355-371. doi: 10.24106/kefdergi.1683483

INTRODUCTION

Education enables the individual to become competent and responsible members of society, equipping them to contribute effectively to the environment and the world around them. A key factor in the effective realization of this process is the individual's capacity to learn. Learning is defined as a dynamic process in which an individual gains knowledge, skills, attitudes, or values through experience, interaction, and education and ensures these achievements become permanent by reinforcing them over time (Khorram et al., 2024). This process also involves the development of the individual in cognitive, affective, and psychomotor domains and is usually shaped by environmental factors, teaching methods, and personal efforts. Learning brings about various changes in students. These changes include transformations in knowledge, skills, attitudes, values, motivation, reasoning skills, and behaviours. Evaluating these changes provides feedback to the student, referred to as the learner, and to the teacher. Drawing from the provided explanations, it becomes evident that rigorous evaluation is essential in education; learning is measured using a diverse array of specialized assessment tools, which are crucial for accurately capturing and understanding every facet of the learning process.

Education uses various measurement tools, which should be designed in accordance with their intended purpose. In other words, the validity and reliability of the measurement tool applied must be established (Gönen et al., 2011). Measurement, which is indispensable in education, provides information about the degree, level, and learning process of the student. It also indicates how changes should be made in the learning process and in which direction the method should evolve. For these reasons, the measurement process uses various measurement methods and techniques. One of these is multiple-choice achievement tests (Çetin & Çakan, 2010). In the Turkish education system, multiple-choice tests are generally preferred when measuring and evaluating students (Akbulut & Çepni, 2013). While there are many measurement and evaluation techniques such as gap filling, true-false, word matching, concept mapping, and short answer questions, the reason for choosing multiple-choice tests is that they are easy, understandable, and useful in terms of both time and application while measuring students' achievements (Karadağ, 2014). Additionally, multiple-choice tests are the most preferred measurement tool for assessing both simple and complex concepts and covering questions about the whole acquisition (Demir, 2012). In this context, beyond the general contribution of multiple-choice tests in measuring knowledge, the use of achievement tests that comprehensively reveal the qualitative gains students acquire during the instructional process supports a holistic assessment approach in education.

Achievement tests are generally a model designed to assess the degree of learning an individual has acquired in a specific content area as a result of planned instruction or training (Nitko & Brookhart, 2011). A review of the literature reveals numerous achievement tests designed for various topics in science courses, including the following: Force and Motion (İdin & Aydoğdu, 2016; Özcan & Orhan, 2024), the Mystery of the Earth's Crust (Sontay & Karamustafaoğlu, 2017), Simple Machines (Özkan & Muştu, 2018), Change of Matter (Saraç, 2018), Matter and Heat (Soylu, Karamustafaoğlu & Karamustafaoğlu, 2020; Avcı, 2020), Cell and Divisions (Karslı, Karamustafaoğlu & Kurt, 2019), the Solar System and Beyond (Uçar & Aktamış, 2019; Armağan & Demir, 2019; Altan, Yadigaroğlu & Eryılmaz Muştu, 2024), Systems (Keçeci, Yıldırım & Zengin, 2019; Akar, Güneş & Yıldırım, 2023; Özkılıç, Bektaş & Karaca, 2023; Meço & Görgülü Arı, 2024), Heat and Temperature (Ayvacı & Durmuş, 2016), Matter and Its Change (Nacaroğlu, Bektaş & Kızkapan, 2020), Force and Energy (Ermiş & Karaman, 2022), Properties of Matter (Dağ & Karamustafaoğlu, 2023), Propagation of Light (Sevim, Uysal & Demirci, 2021), and Human and Environment (Çiçek Şentürk & Selvi, 2021). Although the units included in the science curriculum have been studied separately by different researchers, and achievement tests have been developed accordingly, these tests and the measurement tools prepared are not equivalent to national-level examinations. This is because national-level exams reflect the variations in science questions over time (Sabri, 2019; Pradana et al., 2020; Kolomuc & Karagölge, 2021; Sidiq et al., 2021). Therefore, skill-based questions help students generate solutions and ideas more easily for problems they encounter or may encounter in various aspects of their lives while also providing them with the opportunity to apply their knowledge in everyday life (Rennie & Parker, 1996).

An analysis of national-level exams in the Turkish education system shows that the exam system, along with the types of questions, undergoes frequent changes. The changes in the question system necessitate modifications in both preparatory resources and teachers' approaches to questions and problem-solving skills. To fully understand this situation, it is essential to examine the historical development of the examination system. One of these changes is the high school transition exam. Between 1998 and 2007, the Secondary Education Institutions Selection and Placement Examination (OKS) was evaluated with a single central exam. Between 2008 and 2012, students were assessed with the Placement Examination (SBS), where students took the exam every year in the 6th, 7th, and 8th grades. From 2013 to 2017, the Transition from Basic Education to Secondary Education (TEOG) assessed students with exams in two separate periods. Since 2018, the High School Entrance System (LGS) exam has been used for evaluation.

The purpose of the LGS exam is to measure students' knowledge and skills. The exam consists of skill-based questions similar to the TIMSS (Trends in International Mathematics and Science Study) and PISA (Program for International Student Assessment) exams conducted worldwide (Şan & İlhan, 2022). These new-generation exam questions allow students to apply their knowledge and skills in real-life situations (Karabulut, Tosunbayraktar, & Kariper, 2022). Through skill-based questions, students develop strategic, analytical, and critical thinking skills and abilities in observation, information gathering, comparison, questioning, and discussion.

A review of the literature reveals the opinions of teachers in different branches about the skill-based questions in Turkish, mathematics, and science tests in LGS (Ersoy & Bayraktar, 2018; Erden, 2020; Ünsal & Kaba, 2022), indicating that such questions contribute to science education and should be included in science education (Ceylan & Orhan, 2023; Yuzuak & Recepkethüda 2022). Achievement tests consist of skill-based questions in different disciplines (Erhan, Doğan, & Haser, 2024; Bozkuş & Özgeldi, 2024). Studies examined the theoretical and conceptual framework of science course skill-based questions (Şan & İlhan, 2022). Karabulut, Tosunbayraktar, and Kariper (2022) examined middle school students' views on skill-based science questions and concluded that skill-based questions are difficult and complex. Ercan and Çalışkan (2023) developed a research inquiry and skill-based science test related to the electrical circuit unit, while Turan and Timur (2023) developed a skill-based achievement test for the solar system. Likewise, Büyükkara (2011) and Sözen & Bolat (2014) conducted achievement test studies related to the sound subject and its outcomes. Additionally, Aksoy and Özcan (2020) conducted a test development study to measure 6th-grade students' achievements related to the "Sound and Its Properties" unit.

Within the scope of the science course, the achievement tests on the subject of sound prepared before 2018 included light and sound units together. However, in the science curriculum updated in 2018, the unit "Sound and Its Properties" is included as a separate topic. Sound and its properties are among the concepts that students have difficulty with in science lessons. The curriculum of the science course, which has been gradually started to be used in classes as of the 2024-2025 academic year, reveals that the acquisition of sound and its properties was removed from the sixth grade and transferred to the 8th grade (MoNE, 2024). Considering the present research, it can be stated that the updated science curriculum was prepared in a way that the importance of skill-based questions and the development of the student's skills of observation, information gathering, comparison, questioning, and discussion in the learning process, and making connections in daily life. The new science curriculum can be considered to integrate constructivist, inquiry-based, and STEM-oriented contemporary educational theories while adopting a holistic approach to skill and value development (MoNE, 2024). The program aims to enable students to engage in active learning through skill-based activities, relate scientific knowledge to daily life for meaningful understanding, and consequently enhance their level of scientific literacy (Ak & Köse, 2024). Teaching sound and its properties in science education is crucial for fostering a comprehensive understanding of wave phenomena, which are fundamental to both physics and everyday experiences. Integrating sound into the curriculum can enhance student engagement and motivation, as it connects abstract scientific concepts with tangible, real-world applications, such as music and acoustics (Ramsey, 2015; Iliaki, Velentzas, Michailidi, & Stavrou, 2018). Moreover, addressing common misconceptions and difficulties related to sound through innovative pedagogical strategies, such as active learning and contextualized teaching, can significantly improve students' conceptual understanding and retention of scientific principles (Panjaitan, 2016; Rico, González, Azula, & Aranzábal, 2021; Aygün & Hacıoğlu 2022). The literature shows that students face difficulties in teaching the concept of sound and have misconceptions (Syah, 2025; Azahra et al., 2024; Batlolona & Jamaludin, 2024; Guerra-Reyes et al., 2024; Sözen & Bolat, 2014).

Upon reviewing the literature, it becomes evident that a skill-based achievement test for the unit of "Sound and Its Properties" has yet to be developed, and no existing measurement tool is available for recent acquisitions. Therefore, we decided to conduct a study on developing skill-based questions on sound and its properties. By comparing the 2018 science curriculum with the current curriculum on the topic of "Sound and Its Properties", common achievements were identified, and a test was developed to assess these achievements.

Purpose of the Research

This study aimed to develop a skills-based achievement test for the learning outcomes of the unit of "Sound and Its Properties" in the newly implemented science curriculum.

METHOD

Research model

In this study, a survey design was employed as part of the skill-based test development process. A survey design is a process of systematic data collection to identify specific characteristics, behaviours, opinions, or situations in a population. Surveys, tests, or observations are often used in this design. This method aims to reach generalizations by collecting data from large sample groups and is, therefore, a suitable model for statistical analysis (Gömleksiz & Erkan, 2010). In this research, the development of the achievement test comprising skill-based questions involved crafting multiple-choice items by taking into account the objectives of the "Sound and Its Properties" unit in the science curriculum, aligned with the test's purpose. A pilot study was conducted before finalizing the achievement test, and necessary arrangements were made.

Sample

Fraenkel and Wallen (2013) mentioned two types of populations in research. The first is the accessible population, while the second is the target population. In this study, we preferred the accessible population. Ethics committee permissions were obtained before conducting the study. The study group consists of 375 6th-grade students studying the unit of "Sound and Its Properties" in public schools in a metropolitan city and its districts in the Black Sea Region in the 2023-2024 academic year. The study group was determined through convenience sampling. Since the learning outcome was moved to a different grade level in the updated curriculum, sixth-grade students were chosen for the study, as they had already studied the relevant learning outcomes in their coursework.

Research Instrument and Procedure

In order for a measurement tool to be developed and used in education and psychology, validity, reliability, and usefulness must be ensured. The Standards for Educational and Psychological Testing (SEPT, 1999) was examined, which deals with these standards and steps in detail. According to the data obtained from this review, test developers must follow some steps to develop a measurement tool with the desired criteria and characteristics. The stages to be followed in the test development process can be listed as follows: Test development purpose and general test plan, determining the scope, creating the specification table, writing the articles, reviewing the articles, combining test items into one form, conducting a trial application, selecting or correcting items by item analysis, keeping the tested items in a question bank to be applied later.

Before starting this study, the purpose and planning of the test to be developed were specified through a review of the literature. Next, the scope of the test to be developed was determined, specifically identifying which topics or information should be included in the test. A specification table was created according to the framework determined. Questions were prepared and sent to expert opinions based on the specification table. Necessary adjustments were made in light of the feedback provided by the experts. The test was then collected in a form and piloted as a preliminary application, and the validity and reliability of the items were checked. Following the feedback received from the pilot application, adjustments were made to the developed test. Finally, a skill-based achievement test was created and administered to 375 students to measure their success with the new-generation questions on sound and its properties.

For the achievement test, the achievements related to the subject of "Sound and Its Properties" in the 2024 science curriculum were determined (Table 1).

Table 1: Matching the Skill-Based Achievement Test Questions with the Outcomes of the "Sound and Its Properties" Unit

Item Number	Related Learning Outcome Number
26	8.4.1.1.a. Describes the qualities that make up sound.
6,11,19	8.4.1.1.b. Records the data collected about the formation of sound
4,5,7,8,20,27	8.4.1.1.c. Evaluates that sound is formed as a result of vibration and spreads in waves.
3,12,23,24	8.4.2.1.a. Defines the problem of the effect of distance from the sound source and sound intensity on hearing
13,14,	8.4.2.1.b. Determines the cause-and-effect relationships between the distance from the sound source and the effect of sound intensity on hearing.
9,10,21,25	8.4.2.2.a. Describes the transmission, reflection and absorption of sound
16	8.4.2.2.b. Collects and records data on the transmission, reflection and absorption of sound
1,2,15,17,18,22,28	8.4.2.2.c. Evaluates acoustic applications in relation to the properties of sound

The achievements were examined to ensure the content validity of the achievement test consisting of skill-based questions. The prepared questions were designed by directly aligning them with the learning outcomes. Although the 2024 curriculum consists of various skills, the competencies of the skills employed in the problem-solving process are not evaluated within the scope of this study.

In order to ensure the content validity of the achievement test consisting of skill-based questions, some studies were carried out by examining the gains. A specification table was prepared consisting of the common learning outcomes determined and the questions from each learning outcome (Table 2). 28 questions were prepared. In developing the questions, Bloom's Taxonomy was carefully considered. Bloom's Taxonomy is a well-established framework that categorizes learning objectives into hierarchical levels, systematically guiding students' cognitive processes to achieve these objectives (Bloom, 1956; Anderson & Krathwohl, 2001). This structure forms the foundation for Bloom's Taxonomy's preference in preparing skill-based questions. Bloom's Taxonomy facilitates the acquisition of fundamental concepts at the knowledge and comprehension levels, associating these concepts with experimental processes at the application and analysis levels and developing critical thinking and problem-solving skills at the synthesis and evaluation levels. This hierarchy enables teachers to clearly define the cognitive processes students must engage in when designing questions related to the topic of sound. Consequently, it allows for assessing not only students' ability to recall information but also their capacity to apply, analyze, synthesize, and evaluate knowledge. This approach directly contributes to developing students' scientific process skills, such as observation, data collection, experimentation, and inference. Furthermore, Bloom's Taxonomy provides a methodological basis for developing skill-based questions by ensuring that learning objectives are explicitly and measurably defined in the assessment and evaluation process. The instructional programs published by the Ministry of National Education also emphasize the systematic development of students' cognitive processes, reinforcing the adoption of Bloom's Taxonomy in structuring teaching and assessment processes (MoNE, 2024).

In this study, Bloom's Taxonomy is adopted as an academic and practice-based approach to developing skill-based questions on sound. This preference is due to its advantages in clarifying learning objectives, systematically classifying cognitive processes,

and developing objective and comprehensive assessment tools. Table 2 gives the specification table of the test consisting of 28 trial items created according to Bloom's Taxonomy.

Table 2. Specification Table of Test Items

Learning Outcome	Remember	Understand	Apply	Analyze	Evaluate	Create
8.4.1.1.a.		26				
8.4.1.1.b.		6	19		11	
8.4.1.1.c.	7		20	4,5	27	8
8.4.2.1.a.	3, 12, 24				21	
8.4.2.1.b.					13	
8.4.2.2.a.	9, 23, 25	10				
8.4.2.2.b.	16					
8.4.2.2.c	17	1,2, 18, 22, 28				15

The prepared questions were then submitted to expert opinions. The experts consisted of two associate professors, one assistant professor, a PhD candidate research assistant, as well as two science teachers with a master's degree in science education (Appendix 1). In addition, two Turkish teachers were also consulted for the conformity of the questions to the rules. Based on the feedback of the experts, necessary arrangements were made, and some questions were removed from the achievement test. Additionally, two sample questions approved by the experts are provided in Appendix 2.

After adjustments, the final version of the achievement test was prepared, and the pilot was carried out by applying the test to 35 students. Students were given one class hour (40 minutes) to solve the prepared test. The students could read and answer the questions in the skill-based achievement test within the given time. Based on the students' feedback and the data gathered from the test application, issues such as unclear expressions and spelling errors were identified. Necessary revisions were made to the wording of the items, and the confusion was resolved. After these arrangements, the final version of the skills-based achievement test consisting of 28 items was made ready for the main application.

Procedure

The "Skill-Based Achievement Test on Sound and Its Properties" was used as a data collection tool by obtaining ethics committee permission. The achievement test was applied to 375 6^{th}-grade students in public middle schools in the districts of a metropolitan city in the Black Sea Region.

Data Analysis

The data obtained as a result of the pilot application were coded in the SPSS 20 package program as "1" for correct and "0" for incorrect answers. Then, to ensure the reliability of the test, the Cronbach's Alpha reliability coefficient was calculated. The Cronbach's Alpha reliability coefficient takes values between 0 and 1, and the closer the value is to 1, the more reliable it is, which means that it is adequate in terms of reliability (Ercan & Kan, 2004). Based on the data obtained from the pilot application, the Cronbach's Alpha value was calculated as 0.766, which was sufficient to prove the reliability of the achievement test.

The ranges of item discrimination (Table 3) and item difficulty (Table 4) of a reliable test are given in Tables 3 and 4. TestAn package program was used to calculate item discrimination and item difficulty. Based on the item difficulty index, a ratio approaching +1 indicates that the item is relatively easier, whereas a ratio nearing 0 signifies increased difficulty. When preparing the item difficulty indices of the questions, they are expected to take values close to 0.5 (Turgut, 1995). According to Atılgan (2017), as the item difficulty index approaches 0, it becomes difficult, while it becomes easy towards 1 (Table 4).

Table 3. Item Selection Criteria According to Item Discrimination Indices

Item Discrimination Index	**Item Selection Decision**
0.19 and less	Item to be excluded from the test
between 0.20 and 0.29	Revisable item
between 0.30 and 0.39	Good item can be included in the test
0.40 and higher	Very good item can be included in the test

Table 3 shows the item discrimination indices to be taken as reference for the test questions. According to the discrimination range, it is determined which items should be included in the test, which ones should be removed, and which ones should be revised. A very good item means that the item discrimination index is 0.40 and above. Good items are between 0.30-0.39, and if the value is between 0.20-0.29, it means that the item should be revised. If the value is less than 0.19, the item should be removed from the test (Turgut, 1995).

Table 4. Item Evaluation According to Item Difficulty Indices

Item Difficulty Index	Evaluation of the Item
0.00-0.29	Difficult
0.30-0.49	Medium Difficulty
0.50-0.69	Easy
0.70-1.00	Very Easy

In light of the explanations above, the data were analyzed with the TestAn test analysis program. During the analysis, item discrimination and item difficulty indices of each item were examined separately. Analyses and comments for each item are given in the findings section. In addition, the Kuder-Richardson 20 (KR-20) formula was calculated to find the reliability coefficient of the test, which was found to be 0.77 (r). The reliability coefficient value is within the accepted range according to the values in the literature.

Data Analysis and Interpretation

The "Skill-Based Achievement Test on Sound and Its Properties" prepared was applied to 375 students. The answers given by the students to the multiple-choice questions were entered into the TestAn package program. All answers given by the students to 28 questions were analyzed in this program. The appropriateness of the distractors, the number of correct and incorrect answers, the validity and reliability of each item, and the item difficulty and discrimination indices of the 28 questions were calculated. In line with these data, the items that should be removed from the test and the questions that should be revised were identified.

Validity and Reliability

The data obtained in the pilot application were coded in the SPSS 20 package program as "1" for correct and "0" for incorrect. The Cronbach's Alpha value was found to be 0.766, and the test was determined reliable due to the internal consistency coefficient (Figure 1). The achievement test prepared in the first stage was applied to 375 6th-grade students. TestAn Test Analysis program was used for the analysis of the application result and the Cronbach's Alpha value of the achievement test was found to be 0.80.

Reliability Statistics

Cronbach's Alpha	N of Items
,766	28

Figure 1. Cronbach's Alpha Value of the Test

FINDINGS

Findings Related to the Questions in the Achievement Test

After the pilot study, adjustments were implemented in the achievement test, resulting in the development of a skill-based test comprising 28 questions. As a result of the application, the data of each item were used in the TestAn program, and item discrimination and item difficulty indices were calculated. The findings of item difficulty indices and item discrimination indices for each item are given below.

Table 5 presents the output of the TestAn package program for the first item of the achievement test. For all the items in the tables, p represents the item difficulty index, D denotes the item discrimination index, and * denotes the correct answer.

Table 5. Item Analysis Table for Item 1

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	53	44	24	254	p=0.62
Percentage of responses	14	12	6	68	D=0.46

p: Item difficulty index D: Item discrimination index, *the correct answer.

Table 5 indicates that item 1 demonstrated a very good discrimination power (D=0.46) and an appropriate difficulty level (p=0.62). Consequently, this item was retained in the test.

Table 6. Item Analysis Table for Item 2

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	66	33	264	12	p=0.65
Percentage of responses	18	19	70	38	D=0.50

Table 6 indicates that item 2 was easy (p=0.65) and exhibited very good discrimination power (D=0.50. Therefore, it was included in the test.

Table 7. Item Analysis Table for Item 3

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	21	41	30	283	p=0.69
Percentage of responses	6	11	8	75	D=0.44

Table 7 shows that item 3 was easy (p=0.69) with very good discrimination power (D=0.44, leading to its inclusion in the test.

Table 8. Item Analysis Table for Item 4

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	156	79	34	106	p=0.41
Percentage of responses	42	21	9	28	D=0.38

Table 8 indicates that item 4 had moderate difficulty (p=0.41) and good discrimination power (D=0.38). Therefore, it was included in the test.

Table 9. Item Analysis Table for Item 5

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	33	72	233	37	p=0.55
Percentage of responses	9	19	62	10	D=0.51

Table 9 presents that item 5 had medium difficulty (p=0.55) and very good discrimination power (D=0.51), leading to its inclusion in the test.

Table 10. Item Analysis Table for Item 6

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	273	47	17	38	p=0.67
Percentage of responses	73	12.5	4.5	10	D=0.48

Table 10 shows that item 6 was easy (p=0.67) with very good discrimination power (D=0.48). Hence, it was included in the test.

Table 11. Item Analysis Table for Item 7

Choice	A	B*	C	D	Analysis of the TestAn program
Frequency of Response	45	242	40	48	p=0.60
Percentage of responses	12	64	11	13	D=0.68

Table 11 indicates that item 7 was easy (p=0.60) and had very good discrimination power (D=0.68). Therefore, it was included in the test.

Table 12. Item Analysis Table for Item 8

Choice	A	B*	C	D	Analysis of the TestAn program
Frequency of Response	35	28	272	40	p=0.69
Percentage of responses	9	7	73	11	D=0.55

Table 12 indicates that item 8 was easy (p=0.69) with very good discrimination power (D=0.55). Consequently, item 8 was included in the test.

Table 13. Item Analysis Table for Item 9

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	308	15	30	22	p=0.73
Percentage of responses	82	4	8	6	D=0.41

Table 13 shows that item 9 was easy (p=0.73) with very good discrimination power (D=0.41. Therefore, it was included in the test.

Table 14. Item Analysis Table for Item 10

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	276	26	37	36	p=0.67
Percentage of responses	73	7	10	10	D=0.52

Table 14 indicates that item 10 had a difficulty index of p=0.67 and a very good discrimination power of D=0.52. It was hence included in the test.

Table 15. Item Analysis Table for Item 11

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	57	25	140	153	p=0.37
Percentage of responses	15	7	37	41	D=0.31

Based on Table 15, item 11, with an item difficulty index of p=0.37 and discrimination power of D=0.31, was of medium difficulty and had high discrimination, leading to its inclusion in the test.

Table 16. Item Analysis Table for Item 12

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	294	15	28	38	p=0.67
Percentage of responses	78	4	8	10	D=0.59

Table 16 above indicates that item 12 was easy (p=0.67) and had very good discrimination power (D=0.59). Therefore, it was included in the test.

Table 17. Item Analysis Table for Item 13

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	58	25	96	196	p=0.49
Percentage of responses	15	7	26	52	D=0.49

Based on the analysis in Table 17, item 13 was identified as having moderate difficulty (p=0.49) and very good discrimination power (D=0.49), leading to its inclusion in the test.

Table 18. Item Analysis Table for Item 14

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	146	138	43	48	p=0.37
Percentage of responses	39	37	11	13	D=0.35

Based on the analysis in Table 18, item 14 was found to be of medium difficulty (p=0.37) with good discrimination power (D=0.35), leading to its inclusion in the test.

Table 19. Item Analysis Table for Item 15

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	120	63	141	51	p=0.44
Percentage of responses	32	17	37	14	D=0.42

Table 19 above shows that item 15 was easy according to the item difficulty index (p=0.44) and had very good discrimination power (D=0.42). Therefore, it was included in the test.

Table 20. Item Analysis Table for Item 16

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	277	27	46	25	p=0.67
Percentage of responses	74	7	12	7	D=0.63

Table 20 shows that item 16 was easy (p=0.67) with very good discrimination power (D=0.63), leading to its inclusion in the test.

Table 21. Item Analysis Table for Item 17

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	62	34	68	211	p=0.52
Percentage of responses	17	9	18	56	D=0.59

Table 21 indicates that item 17, with an item difficulty index of p=0.52 and discrimination power of D=0.59, was easy and highly discriminative, leading to its inclusion in the test.

Table 22. Item Analysis Table for Item 18

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	64	70	50	191	p=0.49
Percentage of responses	17	19	13	51	D=0.59

Table 22 shows that item 18 had moderate difficulty (p=0.49) and excellent discrimination power (D=0.59), leading to its inclusion in the test.

Table 23. Item Analysis Table for Item 19

Choice	A	B*	C	D	Analysis of the TestAn program
Frequency of Response	38	252	29	56	p=0.61
Percentage of responses	10	67	8	15	D=0.49

Table 23 indicates that item 19, with a difficulty index of p=0.61 and discrimination power of D=0.49, was easy and highly discriminative, leading to its inclusion in the test.

Table 24. Item Analysis Table for Item 20

Choice	A*	B	C	D	Analysis of the TestAn program
Frequency of Response	254	50	41	30	p=0.67
Percentage of responses	68	13	11	8	D=0.46

Table 24 indicates that item 20 was easy (p=0.67) with very good discrimination power (D=0.46), leading to its inclusion in the test.

Table 25. Item Analysis Table for Item 21

Choice	A	B*	C	D	Analysis of the TestAn program
Frequency of Response	64	183	89	39	p=0.52
Percentage of responses	17	49	24	10	D=0.40

Table 25 reveals that item 21, with a difficulty index of p=0.52 and discrimination power of D=0.40, was both easy and highly discriminative, leading to its inclusion in the test.

Table 26. Item Analysis Table for Item 22

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	78	55	186	56	p=0.49
Percentage of responses	21	14	50	15	D=0.65

Table 26 indicates that item 22 had moderate difficulty (p=0.49) and very good discrimination power (D=0.65), making it a suitable item for inclusion in the test.

Table 27. Item Analysis Table for Item 23

Choice	A	B*	C	D	Analysis of the TestAn program
Frequency of Response	42	227	57	49	p=0.58
Percentage of responses	11	61	15	13	D=0.65

Table 27 indicates that item 23, with a difficulty index of p=0.58 and discrimination power of D=0.65, was both easy and highly discriminative, thus included in the test.

Table 28. Item Analysis Table for Item 24

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	67	90	177	41	p=0.47
Percentage of responses	18	24	47	11	D=0.47

Table 28 shows that item 24, with moderate difficulty (p=0.47) and very good discrimination power (D=0.47), was suitable to be included in the test.

Table 29. Item Analysis Table Item 25

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	63	77	31	204	p=0.54
Percentage of responses	17	21	8	54	D=0.72

Table 29 shows that item 25, with a difficulty index of p=0.54 and discrimination power of D=0.72, was easy and highly discriminative, leading to its inclusion in the test.

Table 30. Item Analysis Table for Item 26

Choice	A	B	C	D*	Analysis of the TestAn program
Frequency of Response	201	93	41	40	p=0.52
Percentage of responses	53	25	11	11	D=0.40

Table 30 reveals that item 26 was easy (p=0.52) with good discrimination power (D=0.46) and thus included in the test.

Table 31. Item Analysis Table for Item 27

Choice	A	B	C*	D	Analysis of the TestAn program
Frequency of Response	77	80	174	44	p=0.46
Percentage of responses	21	21	46	12	D=0.28

According to Table 31, item 27 exhibited medium difficulty (p=0.46) and a discrimination index of 0.28, indicating the need for revision. Consequently, item 27 was excluded from the final test.

Table 32. Item Analysis Table for Item 28

Choice	A	B	C*	D*	Analysis of the TestAn program
Frequency of Response	38	45	228	63	p=0.61
Percentage of responses	10	12	61	17	D=0.36

Table 32 shows that item 28 was easy (p=0.61) with good discrimination power (D=0.36) and thus included in the test.

Table 33 summarizes the difficulty and discrimination indices of the 28 test items.

Table 33. Item Difficulty and Item Discrimination of Test Items

Item No	p	D	Item No	P	D
1	.62	.46	15	.44	.42
2	.65	.50	16	.67	.63
3	.69	.44	17	.52	.59
4	.41	.38	18	.49	.59
5	.55	.51	19	.61	.49
6	.67	.48	20	.67	.46
7	.60	.68	21	.52	.40
8	.69	.55	22	.49	.65
9	.73	.41	23	.58	.65
10	.67	.51	24	.47	.47
11	.37	.31	25	.54	.72
12	.67	.59	26	.52	.40
13	.49	.49	27	.46	.28*
14	.37	.35	28	.61	.36

Accordingly, the item marked with * was removed from the final test due to its discrimination index falling between 0.20-0.29.

Table 34 shows the evaluation of the 28 questions in the achievement test.

Table 34. Evaluation of Items According to the Item Discrimination Index

Item Discrimination Index	Evaluation of Item
0.40 and bigger	1.2.3,5,6,7,8,9,10,12,13,15,16,17,18,19,20,21,22,23,24,25,26
0.30- 0.39	4,11,14,28
0.20- 029	27
0.19 and less	-

Table 34 reveals that no item had an item discrimination index of 0.19 and below; item 27 was in the range of 0.20-0.29 per the item discrimination index; therefore, the item needs to be revised or removed. Hence, item 27 was removed. The remaining questions were appropriate in terms of item discrimination.

DISCUSSION AND CONCLUSION

In the study, a total of 27 multiple-choice descriptive achievement test questions were developed through an examination of PISA, TIMSS, various achievement tests, relevant resources, and previous studies. The aim was to construct an achievement test comprising skill-based questions for the 8th grade "Sound and Its Properties" subject as delineated in the renewed science curriculum (MoNE, 2024). This section includes a discussion of the findings of the developed test in relation to the existing literature.

A review of the literature on the development of an achievement test with validity and reliability revealed studies that followed similar steps (Avcı, 2019; Sontay & Karamustafaoğlu, 2020; Sarıçetin, 2021; Aksoy & Özcan, 2020; Kurt, Aydın, & Bekereci 2023). The similarities between these studies and the current one include the creation of a question pool, seeking expert opinions, and revising or removing items as needed to ensure validity and reliability. The differences include that the current study was conducted for the renewed 2024 science curriculum in the subject area of sound and its properties. That being said, the most significant difference is that our study consists of skill-based questions.

An examination of the literature on skill-based questions indicates that the study by Turan and Timur (2023) on the Solar System unit involved the development of a question pool, the revision of selected items through validity and reliability assessments, the elimination of certain questions, and the solicitation of expert opinions—all aimed at ensuring the questions were skill-based. In contrast, the study was conducted within the framework of the renewed 2024 science curriculum and specifically addressed the domain of sound and its properties.

Within the scope of the theoretical and conceptual framework for skill-based questions in science, it is important to answer whether students have attitudes, prejudices, and expectations toward these questions (Şan & İlhan, 2022). In this respect, our study responds to the current expectations and needs. Furthermore, the present study may serve as a model by emphasizing the significance of language use and delineating essential elements in the construction of skill-based questions. These elements include the development of such questions, the definition of the scope, the establishment of theoretical and conceptual frameworks, the design of questions that meet students' expectations, and the formulation of questions in a clear and concise manner rather than in an overly lengthy or complex form (Şan & İlhan, 2022).. In this study, questions were developed by establishing the theoretical and conceptual framework of the unit of "Sound and Its Properties", which is part of the 8th-grade outcomes of the revised science curriculum.

As part of the study, a skill-based achievement test focusing on the subject of "Sound and Its Properties" was created. In line with this purpose, the achievement test consists of questions whose validity and reliability have been ensured. While developing this achievement test consisting of skill-based questions, the followed the steps suggested by Crocker and Algina (2006) as test development steps. In the implementation steps, the purpose and framework of the subject were first determined. In line with the determined purpose, specification tables were prepared for the content validity of the subject. Then, an item pool consisting of 28 questions was created for the questions of the test. While preparing the questions in the item pool, international TIMSS and PISA exams, as well as national LGS questions, were used, besides studies and resources on this subject previously available in the literature. The literature includes studies where the item pool was prepared using a similar approach (Özcan & Orhan, 2024; Saylan Kırmızıgül & Kaya, 2019). Expert opinions were taken for each question per the specification table prepared. With the feedback received from the experts, the questions became ready. The pilot application, which included the pre-application of the 28-question skill-based achievement test created following the expert opinions, was carried out. The test was applied to 35 students studying in the 6th grade for the pilot application. As a result of the application, issues such as spelling mistakes, incorrect word usage, Turkish sentence disorders, inaccuracies, and insufficient time were corrected. Finally, the validity and reliability of the test were examined by analyzing the items in the pilot application, and the Cronbach's Alpha value was found to be 0.766, indicating that the test was valid and reliable.

The skill-based achievement test developed was applied to 375 6th grade students, and the results were analyzed using the TestAn package program. Each item was analyzed separately in detail. As a result of the analyses, the item discrimination and item

difficulty indices for the items were calculated. Based on this analysis, questions that did not meet the required item index and difficulty standards were removed, and the final set of test questions was selected.

Item analysis is very useful in calculating the success criteria of students as well as developing a measurement tool (Bichi, 2015). The item analysis of the achievement test consisting of skill-based questions on the subject of "Sound and Its Properties" revealed that 23 of the 28 items had an item discrimination index of 0.40 and above, four items were between 0.30-0.39, while one item was between 0.20-0.29. Question 27, which was between 0.20-0.29, was removed from the test. According to extant literature, an item discrimination index of 0.4 or higher is deemed acceptable (Keçeci, Yıldırım, & Zengin, 2019; Ayvacı & Durmuş, 2016). Consequently, the questions in the achievement test are structured in a way that effectively distinguishes between students.

The item analysis results showed that the item difficulty index values of the items in the test were between 0.28 and 0.72. The average item difficulty index value of the achievement test consisting of skill-based questions developed according to the TestAn results was found to be 0.6. An item difficulty index of 0.6 indicates that it is a medium difficulty achievement test.

The reliability coefficient of the "Skill-based Achievement Test on Sound and Its Properties" was found to be 0.80. The literature on achievement test development includes studies with similar results (Özkılıç, Bektas, & Karaca, 2023; Dağ & Karamustafaoğlu, 2023; Boz, Bostan Sarıoğlan, & Özcan, 2022). On the other hand, an item must be greater than 0.70 to be reliable. Therefore, as a result of the analysis, the KR-20 value was determined as 0.8. Since this value is greater than 0.7, the developed test was deemed reliable.

A specification table and item pool were prepared for the content validity of the study. Expert opinions were taken. In addition to the opinions of experts in the field of science education, the opinions of teachers working in the field were also taken. Furthermore, the opinions of Turkish teachers were also taken in order to avoid sentence structure and expression errors. The validity of the test was ensured with the expert opinions. This study aligns with extant research in the literature, wherein expert opinions were solicited during the development of achievement tests in science education. Such an approach underscores the importance of expert input in enhancing the validity and reliability of these assessments. (Meço & Görgülü Arı, 2024; Çiçek Şentürk & Selvi, 2021).

RECOMMENDATIONS

In conclusion, a valid and reliable measurement tool was developed through the achievement test development study, specifically designed for skill-based questions at the middle school level. To ensure continuous improvement, it is recommended to regularly evaluate and update the tool, incorporating feedback to refine its content and format. Additionally, support materials and guides with sample questions should be provided to help students prepare for these skill-based questions. Performance analysis of test results is crucial to identify students' strengths and weaknesses, guiding instructional strategies and curriculum enhancements. Establishing feedback mechanisms with teachers and students will help in continuously refining the tool and the testing process. Research should be conducted to assess the tool's effectiveness and its impact on students' academic performance, ensuring inclusivity across different student groups. These efforts will contribute to a more accurate and comprehensive evaluation of students' skills.

It is important to note that this research was conducted exclusively with students from a specific region and within a limited time frame. Additionally, uncontrollable variables such as individual differences among participants, varying levels of motivation, and external factors could influence the results. Furthermore, the cultural and social backgrounds of the students may also impact the outcomes. In light of the findings obtained from this study, test development studies can be carried out with different samples by taking into account the limitations mentioned.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The first and third authors contributed to writing the scale items, formulating the problem statement of the article, and collecting the data. The first and second authors performed the data analysis, while all of the authors collaborated on writing the discussion and recommendations section. The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

Ethical committee approval for this study was obtained from the Ethics Committee of Ondokuz Mayıs University (Number of Decisions:2024-569; Date: 31.05.2024.

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Appendix 1. Expert Opinions

Item No	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Final Decision
1	Understand	Understand	Understand	Understand	Understand	Understand	Understand
2	Understand	Understand	Understand	Understand	Understand	Understand	Understand
3	Remember	Remember	Remember	Remember	Remember	Remember	Remember
4	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze
5	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze
6	Understand	Understand	Understand	Understand	Understand	Understand	Understand
7	Remember	Remember	Remember	Remember	Remember	Remember	Remember
8	Create	Create	Create	Create	Create	Understand	Create
9	Remember	Remember	Remember	Remember	Remember	Understand	Remember
10	Understand	Understand	Understand	Remember	Understand	Understand	Understand
11	Evaluate	Evaluate	Evaluate	Analyze	Evaluate	Evaluate	Evaluate
12	Remember	Remember	Remember	Remember	Remember	Understand	Remember
13	Evaluate	Evaluate	Evaluate	Understand	Evaluate	Evaluate	Evaluate
14	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze	Analyze
15	Create	Create	Create	Create	Create	Create	Create
16	Remember	Remember	Remember	Remember	Remember	Remember	Remember
17	Remember	Remember	Remember	Remember	Remember	Remember	Remember
18	Understand	Understand	Understand	Understand	Understand	Understand	Understand

Item No	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Final Decision
19	Apply	Apply	Apply	Analyze	Apply	Apply	Apply
20	Apply	Apply	Apply	Analyze	Apply	Apply	Apply
21	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate
22	Understand	Understand	Understand	Understand	Understand	Understand	Understand
23	Remember	Remember	Remember	Remember	Remember	Remember	Remember
24	Remember	Remember	Remember	Remember	Remember	Remember	Remember
25	Remember	Remember	Remember	Remember	Remember	Remember	Remember
26	Understand	Understand	Understand	Understand	Understand	Understand	Understand
27	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate	Evaluate
28	Understand	Understand	Understand	Understand	Understand	Understand	Understand

Appendix 2. Example Questions

1. Example question in the application stage according to Bloom's taxonomy.

Ali is curious whether the sound level he hears differs depending on the medium in which the objects are located.

Therefore, as shown in pictures I, II, and III, Ali takes a domino piece and listens to the sounds produced by tapping it: in Figure 1, in the air; in Figure 2, inside a container filled with water; and in Figure 3, on a table. Which conclusion did Ali reach from his experiment?

A) Sound travels faster in a liquid medium.

B) The speed of sound propagation varies depending on the medium.

C) Sound is heard the same in every medium.

D) The sound level is higher in the air.

2. Example question in the evaluation step according to Bloom's taxonomy.

In the science class, the teacher set up the apparatus shown in the figures so that students could observe the propagation characteristics of sound in different media.

Figure 1

Figure 2

Figure 3

In these setups, the speaker used as the sound source is located as follows: in Figure 1, on a table; in Figure 2, inside a glass container filled with air; and in Figure 3, inside an open container filled with water. During the experiment, the speakers produced the same sound wave at the same intensity simultaneously. However, listeners placed at equal distances from the setups heard the sounds differently depending on the medium.

According to the experiment:

I. Sound propagates in a vacuum.

II. The speed of sound in water is greater than the speed of sound in air.

III. When the medium through which sound is transmitted changes, the sound heard remains the same.

Which of the above statements is correct?

A) Only I

B) Only II

C) I and II

D) I, II and III

Kastamonu Education Journal, 2025, Vol. 33, No:2, 372-388
doi: 10.24106/kefdergi.1683488

| Research Article / Araştırma Makalesi |

An Action Research on the Utilization of Formative Assessment Components in Online Environments in Science Education

Fen Bilimleri Öğretiminde Çevrimiçi Ortamlarda Biçimlendirici Değerlendirme Bileşenlerinin Kullanılmasına Yönelik Bir Eylem Araştırması

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Keywords

1.Formative assessment
2. Collaborative action research
3.In-service teacher training
4. Science education
5. Science teacher

Anahtar Kelimeler

1. Biçimlendirici değerlendirme
2. İşbirlikçi eylem araştırması
3. Hizmet içi öğretmen eğitimi
4. Fen eğitimi
5. Fen bilimleri öğretmeni

Received/Başvuru Tarihi
25.09.2024
Accepted / Kabul Tarihi
20.04.2025

Abstract

Purpose: This research aimed to identify the utilization status of formative assessment components by teachers and analyze the process of addressing the problems encountered in these components.

Design/Methodology/Approach: The research was designed considering Stringer's (2007) model supporting the collaborative action research process. Weekly action cycles were planned with teachers during the research. Data collection tools for the study included video recordings (classroom observations), teacher interviews, researcher field notes, lesson plans, planning and reflection meetings with teachers, and meetings with the validation committee. Data analysis in this research was conducted using descriptive analysis and constant comparative analysis. Interview and observation data, along with lesson plans, were analyzed by the researcher after each action cycle, based on the 'formative assessment classroom observation form' created, to determine the extent to which each teacher used formative assessment components in their lessons. Data were also shared with the validation committee to complete evaluations related to formative assessment components for each teacher. Upon examining the development of teachers' formative assessment components, it was observed that two teachers reached expert levels in all components, while one teacher reached an expert level in all components except for peer assessment.

Findings: Factors generally influencing the use of formative assessment components by teachers, based on the findings of this study, included teachers' instructional beliefs and attitudes, collaboration and adequate support, time, experience, and standardized tests, as well as teachers' educational philosophies and their utilization of online learning environments. The findings of the study were discussed in relation to the literature, and various recommendations were provided to practitioners to contribute to the use of formative assessment in classroom practices and to researchers aiming to improve teachers' formative assessment practices.

*Highlights: F*actors generally affecting the use of formative assessment components by teachers can be stated as teachers' pedagogical beliefs and attitudes, collaboration and adequate support, time, experience, and centralized exams, teachers' educational understanding, and their use of online learning environments.

Öz

Çalışmanın amacı: Bu araştırmada, öğretmenlerin biçimlendirici değerlendirme bileşenlerini kullanma durumlarının ortaya konulması ve bu bileşenlerde ortaya çıkan problemlerin giderilmesi sürecinin analiz edilmesi amaçlanmıştır.

Materyal ve Yöntem: Bu araştırma, öğretmenlerin biçimlendirici değerlendirme uygulamalarını geliştirmeyi amaçlamakta olup, işbirlikçi eylem araştırması yöntemiyle gerçekleştirilmiştir. Araştırma süreci, işbirlikçi eylem araştırması yaklaşımını destekleyen Stringer (2007) modeline dayalı olarak tasarlanmıştır. Bu doğrultuda, öğretmenlerle haftalık eylem döngüleri planlanmıştır. Araştırmada veri toplama araçları olarak video kaydı (ders gözlemi), öğretmen görüşmeleri, araştırmacının saha notları, ders planları, öğretmenlerle yapılan planlama ve yansıtma toplantıları ile geçerlik komitesi toplantıları kullanılmıştır. Veri analizinde betimsel analiz ve sürekli karşılaştırmalı analiz yöntemlerinden yararlanılmıştır. Görüşme ve gözlem verileri ile ders planları, her eylem döngüsü sonunda araştırmacı tarafından geliştirilen "biçimlendirici değerlendirme sınıf içi gözlem formu" doğrultusunda analiz edilmiştir. Böylelikle, her bir öğretmenin dersinde biçimlendirici değerlendirme bileşenlerini kullanma durumu belirlenmeye çalışılmıştır.

Bulgular: Araştırma sonuçlarına göre, öğretmenlerin biçimlendirici değerlendirme bileşenlerindeki gelişimleri incelendiğinde, iki öğretmenin tüm bileşenlerde uzmanlık düzeyine ulaştığı, bir öğretmenin ise akran değerlendirme bileşeni hariç diğer bileşenlerde uzmanlık düzeyine ulaştığı tespit edilmiştir.

Önemli Vurgular: Çalışmadan elde edilen bulgulara göre, öğretmenlerin biçimlendirici değerlendirme bileşenlerini kullanımlarını etkileyen genel faktörler; öğretimsel inanç ve tutumları, iş birliği ve yeterli destek düzeyleri, zaman yönetimi, deneyim, merkezi sınavların etkisi, öğretim anlayışları ve çevrim içi öğrenme ortamlarını kullanma durumları olarak belirlenmiştir.

This study was produced from the first author's doctoral dissertation, and a part of the study was presented as an oral presentation at the 15th National Congress of Mathematics and Science Education, held at Kafkas University, Kars, TÜRKİYE, on 27–30 September 2023.

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INTRODUCTION

The integration of inquiry-based strategies in science education is essential for enhancing students' critical thinking skills and scientific process skills (National Research Council (NRC), 1996). Teachers who implement these strategies are characterized as open-minded, contemporary, and committed to continuous improvement, as they design learning experiences tailored to students' needs by engaging in learning alongside them (Seiley, 1999). Moreover, it is recognized that the primary task of these teachers is to stimulate and interact with students' thoughts and perspectives (Demirel, 2000; Perkins, 1999). The development of knowledge in students' minds is dependent on this interaction with their teachers (Brooks & Brooks, 1993). The sustainability of teacher-student interaction relies on the continuity of assessment activities (Wiliam, 2007). This situation highlights the necessity for assessment practices to be used not only for evaluative purposes but also as a means of enhancing learning (Black et al., 2003; Bonwell, 1991; Gotwals & Birmingham, 2016). In this context, formative assessment, which promotes student learning based on teacher-student interaction, becomes particularly relevant (Black & Wiliam, 1998).

Formative assessment provides ongoing opportunities for teachers to engage in activities that support students' learning by interacting with them (European Commission, 2011). In the framework of formative assessment, the student is positioned at the center of the teaching process and plays an active role. Throughout this process, students engage with both teachers and peers, taking ownership of their own learning. Generally, in the formative assessment process, information about student learning is gathered, analyzed, and then used to provide feedback to students or adjust instruction to help them achieve their learning goals and success criteria (Moss & Brookhart, 2009). Formative assessment inherently encompasses three core dimensions that address what is happening in the classroom at any given moment: Where do we currently stand in terms of learning? What are our learning objectives? What strategies can bridge the gap between the current state and the learning goals? (Hattie & Timperley, 2007; Wiliam & Thompson, 2007; Keeley, 2015; Moss & Brookhart, 2009).

Throughout the formative assessment process, teachers and students assess their current status, compare it with learning goals, and collaborate on strategies to achieve those goals. An analysis of research on formative assessment reveals that key components are identified to sustain this process effectively. These components include explicitly communicating learning objectives and success criteria to students, utilizing various data collection strategies to assess student learning, providing constructive feedback, incorporating self-assessment and peer assessment practices, and planning the next steps in instruction (Buck & Trauth-Nare, 2009; Hattie & Timperley, 2007; Wiliam & Thompson, 2007; Keeley, 2015; Moss & Brookhart, 2009).

For effective and high-quality science teaching to take place, it is essential that formative assessment is actively integrated into classroom learning and teaching activities (Gotwals et al., 2015). The European Commission (2011), in its report *Science Education in Europe*, also emphasized the critical role of formative assessment in achieving the objectives of science education, stating that it is beneficial in both curriculum development and learning and teaching activities. Similarly, a review of the literature highlights that many countries stress the importance of formative assessment in science teaching programs (Australian Institute for Teaching and School Leadership Limited [AITSL], 2011; European Commission, 2011; Ministry of National Education [MEB], 2018; Organisation for Economic Co-operation and Development [OECD], 2005a). In Turkey, the significance of formative assessment in achieving the objectives of science education is explicitly emphasized in the 2018 Science Curriculum, developed in response to these advancements (MEB, 2018).

An examination of the assessment principles within the Science Curriculum (2018) reveals that assessment practices should be ongoing as part of the teaching and learning process (MEB, 2018, p.7). In this context, it is stated that data informing the learning process should be collected through monitoring activities, and the obtained results should be used to enhance teaching and learning activities (MEB, 2018). This approach supports the notion that assessment processes should not be viewed as a standalone procedure but rather as an integral part of instruction (Keeley, 2015; Moss & Brookhart, 2009; Otero, 2006). Therefore, it is evident that the curriculum strongly advocates for the use of formative assessment in classroom practices.

Despite the curriculum's emphasis on formative assessment in classroom practices, studies on teachers' implementation of formative assessment components indicate that this expectation is not being fully realized (Earle, 2014; Gioka, 2009; Gotwals et al., 2015; Haug & Ødegaard, 2015; Ruiz-Primo & Furtak, 2007; Torrance & Pryor, 2001). For instance, in a study aiming to provide a snapshot of formative assessment use in classroom practices, Earle (2014) found that the "self-assessment" component was employed in only 36% of cases, while the "peer assessment" component was used in just 8% of cases. Similarly, Gioka (2009) reported that teachers' use of "feedback" to support student development was significantly lower than their use of judgmental feedback. Additionally, Ruiz-Primo and Furtak (2007), in a study examining the relationship between the effectiveness of formative assessment practices and student performance, found that teachers rarely incorporated the "gathering information about student learning" component. Other studies indicate that the questions teachers pose during classroom interactions tend to target lower-order cognitive skills (Gotwals et al., 2015; Ruiz-Primo & Furtak, 2007) and that the "sharing of learning objectives and success criteria with students" component is insufficiently implemented (Haug & Ødegaard, 2015). Based on these studies, it can be concluded that science teachers' use of formative assessment components is not at an optimal level. This challenge is also evident in online learning environments (Veugen et al., 2022; Zou et al., 2021).

With the use of online environments in instructional practices due to the global pandemic, the ability of teachers to manage online teaching processes has become crucial. In online assessment environments, the use of formative assessment components such as "self-assessment" and "peer assessment" can make the process more interactive and active (Palloff & Pratt, 2009).

Additionally, the use of assessment techniques that are easy and quick to use when collecting information about student learning in online environments can make the teaching process more efficient. For formative assessment to be used in online learning environments, teachers need to be able to use formative assessment components in online environments. Upon reviewing the literature, it is seen that teachers find it challenging to implement formative assessment practices in online learning environments and that individual characteristics such as teacher beliefs and digital literacy are effective factors in the use of formative assessment (Veugen et al., 2022). Furthermore, it is stated that the design of training programs for teachers on online formative assessment may be effective in transforming teachers' understanding and attitudes towards online formative assessment (Zou et al., 2021). However, while limited research explores how teachers employ formative assessment components in online learning environments (Veugen et al., 2022), there remains a notable gap in studies aimed at enhancing teachers' use of formative assessment components in these settings. Based on this gap in the literature, the present study investigates science teachers' implementation of formative assessment components in online learning environments and examines the strategies used to address deficiencies in their application.

This study seeks to answer the following research questions:

1. To what extent do teachers utilize formative assessment components in online learning environments?
2. What strategies are employed to address the identified deficiencies?

METHOD/MATERIALS

Research Design

This study employs the collaborative action research method with the goal of enhancing teachers' formative assessment practices. This research approach seeks to improve instructional strategies and working conditions by heightening teachers' awareness of decision-making regarding their own practices (Chatterton et al., 2007).The study is designed based on Stringer's (2007) model. Stringer (2007) highlights that the core phases of action research unfold in three sequential stages: "look," "think," and "act." In the "look" stage, relevant data are collected, and the examined situation is described broadly. During the "think" stage, the collected data are processed, interpreted, and articulated. Finally, in the "act" stage, strategic plans are developed, executed, and assessed. A diagram illustrating the activities undertaken at each phase of the collaborative action research process throughout the study is presented in Figure 1.

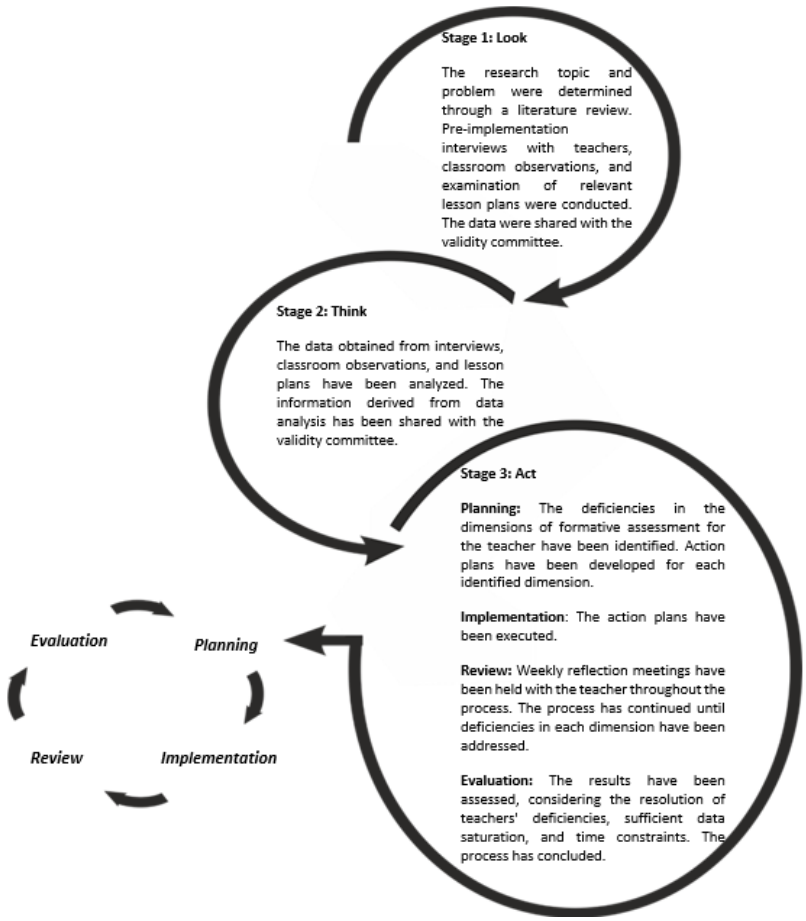

Figure 1. Workflow diagram of the study

Research Group

Three science teachers working in Kastamonu Province participated in this study. In the selection process, their utilization of formative assessment components in online learning environments, willingness to engage in the study, and capacity for collaboration were considered. These teachers were designated as Teacher 1, Teacher 2, and Teacher 3. The socio-demographic profiles of the teachers comprising the study group—including years of professional experience, grade level, educational background, gender, and age—are presented in Table 1.

Table 1. Socio-demographic characteristics of collaborative teachers

Teacher	Years of Professional Experience	Grade Level	Graduation	Gender	Age
Teacher 1	22	5th grade	Bachelor's	Female	40-45
Teacher 2	10	7th grade	Master's	Male	35-40
Teacher 3	20	7th grade	Bachelor's	Female	40-45

Teacher 1: Graduated from a state university with a degree in Physics Education and started professional teaching career in 1998, having been teaching for a total of 22 years. Pursued academic life at the undergraduate level without engaging in advanced academic studies such as master's or doctoral degrees. Attended in-service training courses 2-3 times a year. Mentioned participation in courses with content related to "Assessment and Evaluation". Expressed interest in formative assessment strategies. The class size is 35 students. The school where the teacher works is a state school affiliated with the central district of Kastamonu. The students' socioeconomic levels at the school are moderate to high. The school's success rate is above the provincial average.

Teacher 2: Graduated from a state university with a degree in Science Education and has been in the profession for 10 years. Completed a master's degree in 2019 and is currently continuing doctoral studies in the field of Science Education. The class size is 18 students. The school where the teacher works is a state school affiliated with the central district of Kastamonu. In addition to students coming from the center, there are also students transported from surrounding villages. The students' socioeconomic levels at the school are low to moderate. The school's success rate is below the provincial average.

Teacher 3: Has been teaching in state schools for 17 years. Holds a bachelor's degree in teaching and has received training in STEM and robotic coding. Mentioned working on project-based activities. The class size is 28 students. The school where the teacher works is a state school affiliated with the central district of Kastamonu. The students' socioeconomic levels at the school are high. The school's success rate is well above the provincial average.

Data Collection Tools

The research questions, data collection tools, data collection methods, and details regarding when, from whom, why, for how long, and how many times these methods and tools were used in the study are presented in Table 2.

Table 2. Data collection methods and techniques used in collaborative action research process

Research Questions	Data Collection Tools	From Whom?	Why?	When?	Duration	Quantity
1. How do teachers use formative assessment components?	Video recording (in-class observation)	Classroom environment	Prevention of data loss, General description of the situation	During classroom implementation	53 hours 20 minutes	80 recordings
	Teacher interviews	Teachers	Expression of experience	At the beginning of the process	5 hours	10 interviews
	Researcher field notes	Researcher	Evaluation of the teacher's process	Throughout the research process	Throughout the research process	Throughout the research process
	Lesson plans	Researcher and teachers	Examination of techniques used in lesson plans	Before each implementation	10 hours	20 plans
2. How was the process of addressing identified deficiencies conducted?	Video recording (in-class observation)	Classroom environment	Critical reflections, Identification of change and development, Support of findings	During classroom implementation	56 hours 25 minutes	84 recordings
	Teacher interviews	Teachers	Evaluation of the process	At the end of the process	1 hour 30 minutes	3 interviews
	Teacher planning and	Teachers	Expression of experience,	After each action cycle	10 hours 30 minutes	21 meetings

Research Questions	Data Collection Tools	From Whom?	Why?	When?	Duration	Quantity
	reflection meetings		Evaluation of the process, Critical reflections (review, planning, evaluation)			
	Meetings with the validity committee	Expert researchers	Expression of change and development	After each action cycle	10 hours 30 minutes	21 meetings
	Researcher field notes	Researcher	Evaluation of the teacher's process	Throughout the research process	Throughout the research process	Throughout the research process
	Lesson plans	Researcher and teachers	Examination of techniques used in lesson plans	Before each action cycle	10 hours 30 minutes	21 plans

Data Analysis

In this research aimed at revealing teachers' use of formative assessment components and addressing identified deficiencies, data analysis was conducted using descriptive analysis and constant comparative analysis. Table 3 presents the connections between research questions, data sources, and analytical methods.

Table 3. Connections between research questions, data sources, and analysis methods

Research Questions	Data Sources	Analysis Methods
1. How do teachers use formative assessment components?	Teacher interviews, Researcher field notes, Lesson plans, Meetings with the validity committee, Video recording (In-class observation)	Descriptive analysis
2. How was the process of addressing identified deficiencies conducted?	Teacher planning and reflection meetings, Teacher interviews, Researcher field notes, Lesson plans, Meetings with the validity committee, Video recording (In-class observation)	Descriptive analysis and constant comparative analysis

In this study, during the needs analysis and implementation phase, online classroom observations, teacher interviews, field notes, planning meetings, and validity committee discussions were examined using descriptive analysis. Throughout the process, targeted evaluations were conducted to assess teachers' instructional practices. After ensuring data saturation, constant comparative analyses were performed, and the findings were continuously analyzed.

Initially, after gathering and reviewing the data, an analytical framework was established based on the focused assessment areas. According to this framework, a formative assessment classroom observation form was developed, incorporating seven formative assessment components categorized under three dimensions, and translated into Turkish. In designing the form, items adapted from Dell and Dell (2016) and Gotwals et al. (2015) were utilized to evaluate the relevant instructional dimensions. The initial version of the form was sent to two independent experts for feedback. Based on their recommendations, the finalized version of the form was determined and used to evaluate classroom video recordings in the online environment.

After finalizing the formative assessment classroom observation form, it was completed weekly by the researcher and an expert from the validity committee. While documenting observations, the researcher and expert recorded key instructional behaviors exhibited by teachers across the specified dimensions and components, alongside their evaluative remarks. The researcher and expert engaged in collaborative discussions for each teacher to determine which performance indicators aligned with the formative assessment dimensions and components. Through this consensus-driven process, they established each teacher's weekly formative assessment performance.

Validity and Reliability Studies

In this action research, credibility, transferability, dependability, and confirmability were ensured through several strategies. A validity committee, composed of experts in formative assessment and action research, regularly reviewed the process and provided feedback. Data were collected from six different sources, enabling triangulation, and the entire process was thoroughly documented to enhance transparency and confirmability. Classroom video recordings were coded by two researchers, and inter-coder reliability was calculated as 0.90, indicating high consistency (Miles & Huberman, 1994).

FINDINGS

The findings of the study are presented in two stages: the usage status of formative assessment components by teachers and the process of addressing deficiencies in formative assessment components.

How Do Teachers Utilize Formative Assessment Components?

Table 4 provides performance indicators of three Science teachers participating in the study, indicating their usage of in-class formative assessment components during observed lessons. Analysis results identified deficiencies in the formative assessment components in the online learning environment.

Table 4. Performance Indicators of the In-Class Formative Assessment Observation Form

Formative Assessment In-Class Observation Form							
Dimensions	Sharing learning objectives: Where are we going?	Gathering information about student learning: Where are we now?				Closing the gap/Responding to students: How do we close the gap?	
Components	Sharing learning objectives and success criteria	Types of questions/Obtained information	Strategies for obtaining information	Self-assessment	Peer assessment	Feedback loops information	Instructional decisions/adjustments
Teacher 1	Beginning	Developing	Effective	Beginning	Beginning	Developing	Effective
Teacher 2	Beginning	Beginning	Developing	Beginning	Beginning	Developing	Effective
Teacher 3	Beginning	Effective	Effective	Beginning	Beginning	Developing	Effective

When examining Table 4, it is evident that teachers are at the beginning level in sharing learning objectives and success criteria, self-assessment, and peer assessment components. This suggests that teachers are not fully utilizing these components in their lessons. In the feedback loops component, teachers are at the developing level. It has been found that the feedback provided by teachers is primarily evaluative, focusing on correct answers to the problem or task. It is observed that the feedback is connected to learning objectives, and teachers use students' inquiries to offer feedback.

In the instructional decisions component, teachers are at the effective level. Therefore, teachers collect information about their students' learning throughout the lesson, aligned with learning objectives and success criteria. Teachers also identify misconceptions students have and analyze this information to draw conclusions about their students' strengths and weaknesses. However, there is a need to improve the methods of information collection used by teachers.

Teachers exhibit varied performance levels in the question types/obtained information and strategies for gathering information components. For the question types/obtained information component, the levels, frequencies, and examples of questions used by teachers in pre-implementation lessons according to Webb's depth of knowledge are provided in Table 5.

Table 5. Levels, Frequencies, and Examples of Questions Used by Teachers in Pre-Implementation Lessons According to Webb's Depth of Knowledge

Teacher	Depth of Knowledge Level	Frequency	Example
Teacher-1	Recall and Reproduction	22	All objects on Earth are attracted to each other by a force called gravity. So, do your feet touch the ground because of that force?
	Skills and Concepts	8	Can you think of situations around you where you can see the effect of gravity?
	Strategic Thinking and Reasoning	6	If there were no force, could you sit down? .... What do you think about this?
Teacher-2	Recall and Reproduction	25	If I say an apple weighs 10 kg, would that be incorrect?
	Strategic Thinking and Reasoning	5	How would life be if there was no gravity?
Teacher-3	Recall and Reproduction	10	Can you give examples of secretions produced by the Golgi apparatus?
	Skills and Concepts	12	Why do vacuoles in plant cells grow as they age?

Strategic Thinking and Reasoning	13	If a cell can sustain life with just ribosomes, why are there more organelles in eukaryotic cells? Teacher-3 also questioned their students on why they reached a particular answer.

When the questions asked by teachers to students in the online learning environment were analyzed, it was observed that in the component of question types/obtained information, Teacher-1 was at a developing level, Teacher-2 was at a beginning level, and Teacher-3 was at an effective level. It was observed that Teacher-2 mostly asked single-response, low-depth questions to students. Teacher-1's questions to students were generally low-level, but they also used questions aimed at a higher depth of knowledge. Teacher-3 asked mixed questions ranging from low to high depth of knowledge to students. Teacher-3 also questioned their students on why they reached a particular answer.

When examining the pre-implementation strategies used by teachers to gather information, it was observed that Teacher-1 and Teacher-3 were at an effective level, while Teacher-2 was at a developing level (VCM-1). According to the decision made by the validity committee, at this level, it was observed that Teacher-1 and Teacher-3 employed effective inquiry strategies in the classroom that provided evidence for most of the learning students achieved. For example, Teacher-1, while addressing the learning goal of "measuring the force with a dynamometer" in the 5th-grade Science lesson, unit 3, "measurement of force and friction," asked students questions related to the effects of gravity in daily life and stimulated deeper thinking by posing these questions. It was observed that more than half of the class expressed a desire to participate in the discussion.

"Teacher: Can you think of situations around you where you can see the effect of gravity?

Student: Teacher, sometimes they measure in villages, Teacher.

Teacher: Can't you see the effect of gravity right now?

Student: I'm experiencing it, Teacher.

Teacher: All objects on Earth are attracted to each other by a force called gravity. So, do your feet touch the ground because of that force?

Student: I'm sitting right now.

Teacher: Could you sit down if there was no force? ... What do you think about this?"

Here, the teacher asked the student about situations where gravity could be related to daily life. The teacher deepened the inquiry process based on the student's response. The teacher generally encouraged students to think based on the strengths and weaknesses of student responses relative to the learning objective. The limitation of the teacher was only using the question-answer method. The decision made by the validity committee is to "increase the techniques used by the teacher to obtain data related to student learning and to implement them." The situation regarding this component is similar for Teacher-3 as well.

When examining Teacher-2's strategies for gathering information in the online learning environment, it was observed that they were at a developing level (VCM-1). According to the decision made by the validity committee, Teacher-2 generally did not encourage students to reflect on the strengths and weaknesses of student responses relative to the learning objective. For example, while addressing the achievement of "naming gravitational force acting on mass as weight" in the 7th-grade Science lesson, unit 3 "force and energy," Teacher-2 engaged in question-answer sessions related to the effects of gravity in daily life.

"Teacher: Why do we use these rocket fuels? (Teacher waits for a while, but no response comes from the class) To overcome gravity?

Student: Yes, sir, that's right. We use them to overcome gravity force.

Teacher: How would life be if there was no gravity?

Student: Everything would be flying in the air.

Teacher: So would our life be negatively affected? Positively?

Student: Negatively.

Teacher: Wouldn't there be any positive aspect at all?

Student: Sir, we could jump out of the window during an earthquake."

Here, the teacher provided the correct answers to the questions themselves and did not give students the time needed to find the correct answer (RFN). The questions asked by the teacher directed the students but did not encourage them to think deeply. The decision made by the validity committee is that "the limitation of the teacher is not only using the question-answer method but also not involving the student enough in the learning process. The teacher should diversify the techniques used to obtain data related to student learning and use them to include all students in the class."

How Were the Identified Deficiencies Addressed?

In the process of addressing the gaps in the formative assessment components in the online learning environment, a total of 7 action cycles were conducted with Teacher-1 and Teacher-2, and 5 action cycles with Teacher-3. Each action cycle was planned for 4 class hours of weekly Science lessons. Table 6 provides the formative assessment components included in each action cycle of the teachers and the levels at which these formative assessment components were used by the teacher in these action cycles.

Table 6. Dimensions and Components Included in Teachers' Action Cycles

Dimensions		Sharing learning objectives: Where are we going?	Gathering information about student learning: Where are we now?				Closing the gap/Responding to students: How do we close the gap?	
Components		Sharing learning objectives and success criteria	Types of questions/Obtained information	Strategies for obtaining information	Self-assessment	Peer assessment	Feedback loops information	Instructional decisions/adjustments
T1	Cycle 1	Developing	-	Effective	-	-	-	-
	Cycle 2	Developing	Developing	Effective	-	-	Developing	-
	Cycle 3	Effective	Developing	Effective	Developing	-	Developing	Effective
	Cycle 4	Expert	Effective	Effective	Developing	-	Effective	Effective
	Cycle 5	Expert	Effective	Expert	Effective	Developing	Effective	Expert
	Cycle 6	Expert	Expert	Expert	Effective	Effective	Expert	Expert
	Cycle 7	Expert	Expert"	Expert	Expert	Expert	Expert	Expert
T2	Cycle 1	Developing	Developing	Developing	-	-	-	-
	Cycle 2	Developing	Developing	Developing	-	-	Developing	-
	Cycle 3	Effective	Developing	Effective	Developing	-	Developing	Effective
	Cycle 4	Effective	Effective	Effective	Developing	Developing	Effective	Effective
	Cycle 5	Expert	Effective	Effective	Effective	Developing	Effective	Effective
	Cycle 6	Expert	Expert	Expert	Effective	Effective	Expert	Expert
	Cycle 7	Expert	Expert	Expert	Expert	Expert	Expert	Expert
T3	Cycle 1	Developing	-	Effective	-	-	Developing	-
	Cycle 2	Effective	-	Effective	-	-	Effective	-
	Cycle 3	Expert	Effective	Expert	Effective	-	Effective	Effective
	Cycle 4	Expert	Expert	Expert	Expert	-	Effective	Expert
	Cycle 5	Expert	Expert	Expert	Expert	Developing	Expert	Expert

When examining Table 6, it is observed that in the action cycles, the components of sharing learning objectives and success criteria, as well as obtaining information strategies, are included for each teacher from Cycle 1 onwards. Since it is necessary to include learning objectives and success criteria for each achievement at the initial stage, and considering that the teachers are at the beginning level in this component, it has been included in every cycle for each teacher. In terms of obtaining information strategies, since the strategies that can be used in online learning environments may differ from face-to-face learning environments and in order to prioritize the issues that may arise during implementations, this component has been included in all cycles designed for each teacher. Self-assessment and instructional decisions/regulations components have been included for each teacher from Cycle 3 onwards. The validity committee deemed it appropriate for the self-assessment component to be included in the process only after the information gathering strategies component has become fully usable by the teacher during the implementation process. Thus, including various self-assessment techniques in the action cycles has been facilitated for the implementation of the self-assessment component. The instructional decisions/regulations component, on the other hand, has been deemed appropriate to be implemented before moving on to the next achievement. For the question types/obtained information and feedback loop components, it has been determined which cycles should be included based on the teachers' pre-implementation performance indicators. The peer assessment component has been the last component to be included in the action cycles for each teacher. This decision by the validity committee was made to ensure both the teachers' mastery of the process and the students' learning of the techniques they will use to evaluate each other. Additionally, Teacher-3 only used this component in one cycle during the implementation because they believed that this component could adversely affect the quality of teaching due to their past experiences.

From this point on, the development in each critical formative assessment component for each teacher is provided. The progression in sharing learning objectives and success criteria for Teacher-1, question types/obtained information for Teacher-2, and peer assessment for Teacher-3 is presented.

Teacher-1

Teacher-1 is at the initial level for sharing learning objectives and success criteria component in the online learning environment. During the preparation phase, the teacher engaged in discussions with the researcher on how to create and share learning objectives and success criteria with students. As the action cycles began, Teacher-1 included this component in the introduction part of the lesson.

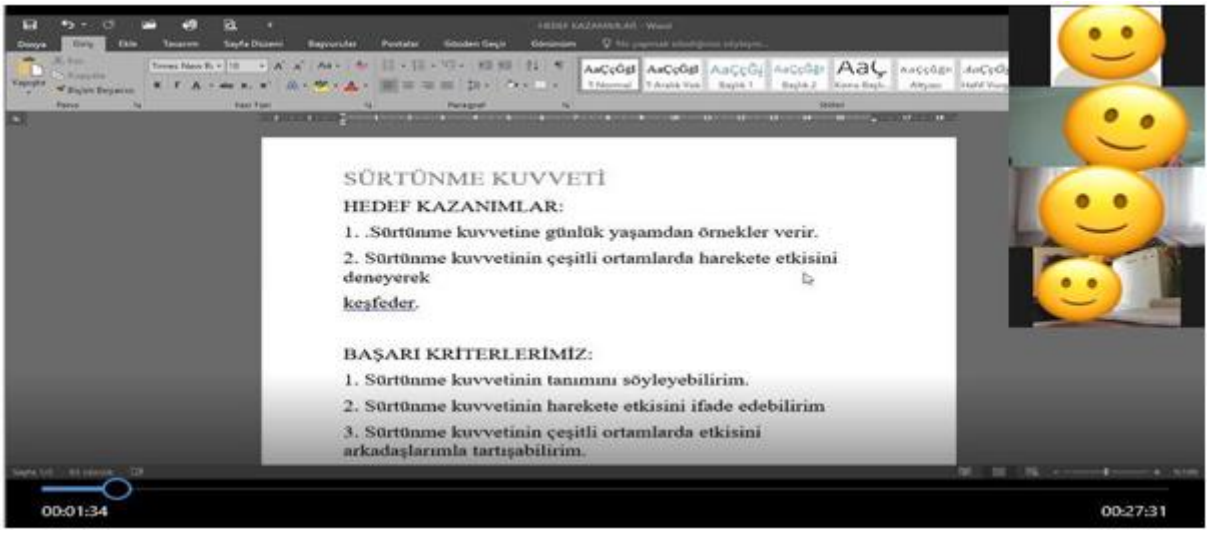

Figure 2. An example of Teacher-1 sharing learning objectives and success criteria during the lesson

Teacher-1 shared the learning objective for the topic of "frictional force" verbally in Cycle 1, as shown in Figure 1, and attempted to collaboratively determine the success criteria with the students by asking, "How do we determine if we have achieved the learning objectives?" However, the students were unable to participate. Consequently, Teacher-1 independently determined the learning objectives and success criteria in Cycle 1 and shared them with the students. The teacher shared some key concepts related to the topic with the students and asked them what they knew about these concepts. The teacher took a guiding role during this process. Providing a specific time for students to write down the success criteria in their notebooks, the teacher later shared the success criterion as "a tangible indicator indicating that we have achieved the learning objectives" (CVR-Cycle 1). Additionally, Teacher-1 shared with the students what the success criteria were and emphasized that the purpose of the lesson was to accomplish these criteria. After giving students three minutes to write down the success criteria in their notebooks, the teacher asked them to review them to understand what they meant. A student's question during this process was as follows: "So, is our goal in this lesson to achieve these criteria?" The teacher confirmed that this was correct (CVR-Cycle 1). Some students had difficulty understanding what the success criteria were at first, possibly because the teacher was introducing this concept into their lessons for the first time, causing some apprehension (RFN-Cycle 1).

After writing down the success criteria in their notebooks, the teacher asked the students to review them, saying, "After writing them down in your notebooks, I want you to review the success criteria. Let's read them again together and see if we have achieved these criteria by the end of the four lessons. At the end of the four lessons, have we been able to fulfill these criteria? Let's look at them together." Students' involvement in the process of creating success criteria began to be observed for Teacher-1 after Cycle 3. Similar processes were observed in subsequent cycles. In the post-implementation interview, Teacher-1 expressed their views on the relevant component:

"First of all, students knowing what they will learn, which topics they will learn in advance, and being more consciously involved in the process made them participate more and they inevitably asked questions about the topics we covered." (Post-I).

Teacher-1 stated that when they included the sharing of learning objectives and success criteria component in their lesson, students took on a more conscious responsibility for what they were going to learn and were able to express the parts they did not understand. At the end of the process, it was decided that Teacher-1 had reached the expert level in the component of sharing learning objectives and success criteria (VCM-3).

Teacher-2

Before the implementation, it was observed that Teacher-2 was at the initial level in the component of question types/obtained information in the online learning environment (VCM-1). Studies were conducted to address the deficiencies of teachers in this component with the prepared action cycles. Training on question types and cognitive levels was provided to address the deficiencies.

According to the decision of the validity committee, the first step for Teacher-2 is for their students to participate in classroom interaction (VCM-1). Because students mostly responded to questions with "yes" or "no." Therefore, alongside the cognitive levels of the questions, student interactions became important during this process (VCM-1). An example dialogue between Teacher-2 and one of their students is provided below (Cycle 4-CVR):

"Teacher: When riding a bicycle, we push the pedal. Why does the bicycle stop after we stop pedaling for a while?

Student: Frictional force reduced the kinetic energy, and it eventually stopped.

Teacher: For example, why does a person descending with a parachute descend slowly?

Student: Because it experiences air resistance. If there were no air resistance, it would fall straight down and crash to the ground rapidly.

Teacher: What if we used an umbrella instead of a parachute? (Continued with another student.)

Student: The umbrella cannot take in much air, so the resistance is low, but the parachute takes in more air, so it descends more slowly.

Teacher: Air resistance causes objects to slow down. A person descending with a parachute makes a safe landing thanks to air resistance reducing their kinetic energy. So, how do we increase air resistance? (Continued with another student.)

Student: We need wider surfaces to increase it.

Teacher: What do we do to decrease it?

Student: We need narrower surfaces, teacher."

In this dialogue, it can be seen that the teacher attempted to maintain classroom interaction, and the students participated in this process. The responses of the students evolved from "yes" and "no" to meaningful sentences. The teacher noted this during the planning and reflection meeting as follows (PRM-4):

"In fact, students also enjoy this process. Participation in the lessons increased with formative assessment. It catches my attention."

This process continued with increasing student participation until Cycle 7 (VCM-2). The cognitive levels of the questions asked by the teacher rose from the recall and reproduction stage to the strategic thinking and judgment stage. This change was observed distinctly after Cycle 4. Examples of questions asked by the teacher are given below:

"What is gravitational force? How does gravitational force change on Earth and other planets?" (CVR-Cycle 4).

"In the 1920s, 30s, and 40s, a method like this was used: high-energy rays were directed at the atom. As a result, the protons, electrons, and neutrons in the atom cannot withstand these rays and break apart. Can atoms naturally break apart like this?" (CVR-Cycle 5).

"The first image shows a green and large representation, while the second image shows a purple and slightly smaller one. Why do you think that is?" (CVR-Cycle 6).

"Here, toothpicks are used to combine the atoms. What does this mean?" (CVR-Cycle 7).

Taking into account the cognitive levels of the questions and classroom interaction, it was determined that the deficiencies of the teacher in this component were addressed, and they reached the expert level (VCM-3).

Teacher-3

Regarding the peer assessment component, Teacher-3 expressed during the pre-implementation interview that they had prior experience with this but believed that their students would unnecessarily criticize each other in class, making the process uncontrollable (Pre-I). Therefore, they did not want to allocate much time to this component in the action cycles (RFN). They only worked on this component in Cycle 5. Initially, Teacher-3 shared the steps of the peer assessment ladder with their students and reached a consensus with them on how they would assess each other before starting the process. In this cycle, Teacher-3 created various criteria and asked the students to assess each other's materials related to mitotic division (CVR-Cycle 5). An example of Teacher-3's work on the peer assessment component is provided in Figure 2.

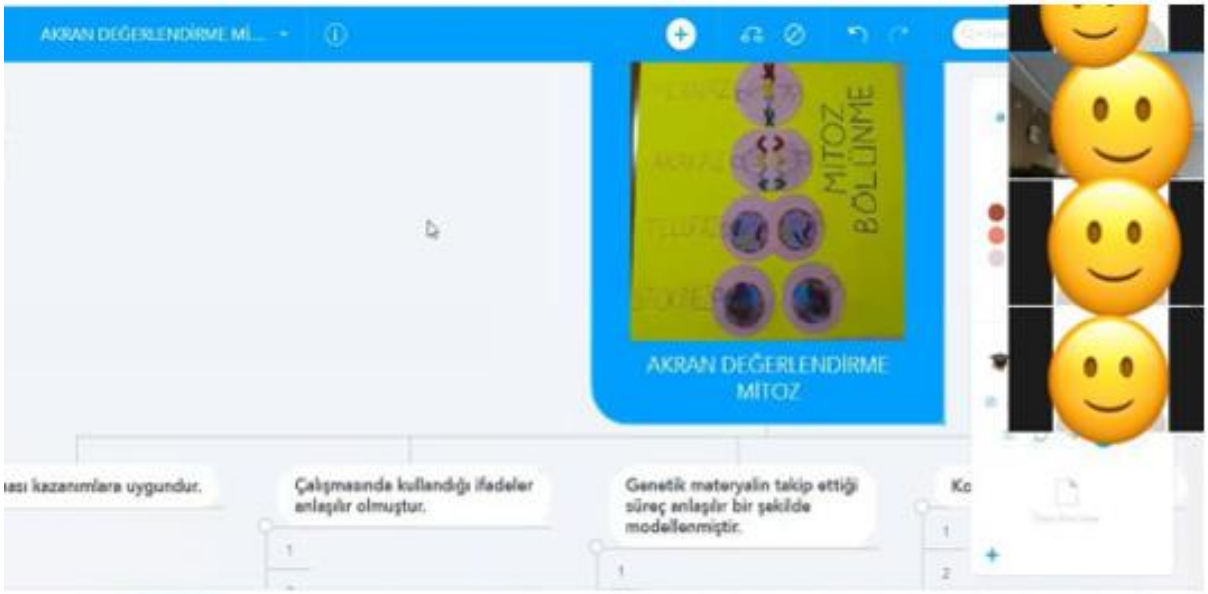

Figure 3. Example of teacher-3's peer assessment activity

When examining Figure 3, it can be observed that Teacher-3 shared the material to be evaluated by the students and the criteria they would use to assess each other. Particularly during the peer assessment process among successful students, difficulties were encountered. Students struggled to accept the opinions of their peers evaluating them. Teacher-3 had to intervene constantly throughout the process (RFN-Cycle 5). During the process, Teacher-3 found it challenging to maintain control in the classroom and stated that they did not consider using this technique again (Post-I). Teacher-3 evaluated this process negatively. During the peer assessment experience, students were stressed, finding it difficult to accept criticisms of their own work. At the end of the process, it is believed that Teacher-3 reached the developing level in the peer assessment component (VCM-3).

Actions Taken to Address Identified Shortcomings

The process of addressing the identified shortcomings in the formative assessment components of science teachers in online learning environments has been detailed for each teacher. Actions taken with teachers for each component, the average number of cycles required, and their progress are provided in Table 7.

Table 7. Process of addressing identified shortcomings

Component	Progress	Average Cycle Count	Actions Taken
Sharing learning objectives and success criteria	Beginner to Expert	4	Determination of learning objectives and success criteria Linking instructional practices with learning objectives and success criteria Involving students in the process of forming learning objectives and success criteria
Question types/obtained knowledge	Beginner to Expert	4	Determining the cognitive levels of questions and including questions with high depth of knowledge in the instructional process Questioning how students reach the answer to the relevant problem "how" and "why" Tasks given to students requiring more strategic and procedural decision-making (short film, video, game, research report)
Strategies for obtaining information	Developing-Expert	4	Utilizing effective inquiry strategies that demonstrate all students learn systematically Active use of pre-prepared questions in the teaching process Consistently clarifying student responses and refining student comments Questioning students for more detailed responses Increasing student involvement in thinking about the problem
Self-assessment	Beginner to Expert	4	Asking students to evaluate their own learning Ensuring students fully understand what to do Structuring the process according to specific criteria to support students
Peer assessment	Beginner to Expert	3	Asking students to evaluate a peer's work and provide feedback to improve its quality Ensuring students fully understand what to do and structuring the process to support students in completing their task Ensuring that peer assessment has a positive impact on the quality of student work
Feedback loops	Developing-Expert	4	Providing students with explanatory feedback on the completion process of tasks (used strategies) and on the task itself Ensuring that feedback is sufficient for students to know what to do next Providing feedback on learning objectives and success criteria Enabling students' questions to provide rich feedback Providing opportunities for students to use feedback meaningfully
Instructional decisions/arrangements	Effective-Expert	3	Using multiple data collection methods to identify students' understanding/misunderstandings or to make inferences about students' strengths and weaknesses Continuously analyzing evidence related to student learning Utilizing the derived inferences and student work or responses to continuously shape instructional decisions.

DISCUSSION AND CONCLUSION

In this section, the findings regarding the use of formative assessment components by teachers before the implementation and the process of addressing identified deficiencies are discussed. The changes and developments in teachers' use of formative assessment components are examined in detail.

The process of using formative assessment in classroom activities began with the sharing of learning objectives and success criteria. It was observed that the teachers participating in the study did not share learning objectives and success criteria with their students in their pre-implementation lessons. In studies examining the use of formative assessment components in classroom practices, limited research has been found on the use of learning objectives and success criteria. One such study by Gotwals et al. (2015) examined the formative assessment practices of mathematics and science teachers who participated in a professional development program on formative assessment using video recordings. In this study, despite receiving training in formative assessment, teachers stated that they had low use of learning objectives in their lessons. Similarly, Haug and Ødegaard (2015), in their study investigating how formative assessment develops conceptual understanding in teaching basic science concepts to primary school teachers, expressed that teachers did not set learning objectives in their lessons before participating

in the professional development program. Similarly, a study by Torrance and Pryor (2001), aimed at researching and improving formative classroom assessment in primary schools, concluded that teachers did not clearly share learning objectives with students. The findings of this study are similar to those of previous research.

In this study, it was found that the questions teachers used in the pre-implementation phase were generally low in cognitive depth. Previous research has also shown that science teachers do not ask questions that involve deep knowledge (Gotwals et al., 2015; İnaltun, 2019). In the evaluation conducted among teachers, three different levels of performance were identified in terms of question types/knowledge components. The teacher who demonstrated the highest performance was determined to have a student group with high inquiry skills, and the school's success was above the district average. This situation indicates that the expected success of students could be high. On the other hand, it was found that the teacher with the lowest performance worked in a school where the success was below the district average, and the expected success of students could be low. As also indicated by Tomanek et al. (2008), student characteristics and success expectations affect science teachers' formative questioning practices. In this study, it was determined that the teacher who demonstrated the lowest level of performance in terms of question types/knowledge components had students with low academic achievements and social communication skills. Low classroom interaction may cause students to provide simple answers to questions, which may lead the teacher to prefer questions at a low cognitive level. Additionally, the current study shows that diversifying data collection tools related to student learning increases student interactions and raises the cognitive levels of questions asked by the teacher. It has been stated that pedagogical content knowledge also affects question types. It has been observed that as the cognitive level of the questions asked by teachers increases, students become aware of their own learning. It has also been determined that giving students wait time after directing questions increases student participation (Harrison, 2013). In this context, it can be concluded that emphasizing pedagogical knowledge is important for teachers to improve their questions and classroom interactions.

In this study, it was determined that teachers generally preferred questioning techniques to focus on student learning in the "knowledge acquisition strategies" component in the pre-implementation phase. This finding is parallel to the findings of similar studies in the literature (Earle, 2014; Bulut 2010). Especially, a study by Earle (2014), which examined the approaches adopted by English schools, revealed that questioning was the most commonly used knowledge acquisition strategy for formative assessment purposes. Another factor to consider in teachers' questioning practices is the purposes of the questions and where they are used during the lesson. In the study, it was observed that teachers generally preferred this technique to assess students' knowledge at the beginning of the lesson, to attract students' interest and attention during the process, and to evaluate students at the end of the lesson. A similar study by Kubat (2018) also examined how teachers use the question-answer technique in the teaching-learning process and reached similar results. A prominent feature of the study is that it was conducted in online learning environments. In the current study, it was observed that teachers who transitioned to online learning environments unprepared due to the global pandemic had difficulty integrating knowledge acquisition strategies that could be used in these environments into their lessons. Önder's (2022) study revealed that the most challenging aspect for teachers during the COVID-19 pandemic was integrating technology into their lessons. This is seen as a supporting factor for the findings of the current study. Additionally, it was emphasized that shortening the duration of online lessons may lead teachers to have difficulty in using alternative assessment methods. This indicates a challenge for teachers in using and integrating technology into their lessons.

In this study, formative assessment techniques that can be used in online learning environments were recommended to teachers during the pre-implementation preparation phase, and how these techniques would be used in lesson plans was determined. This process is generally evaluated positively by teachers. Especially, the implementation of the 'think-pair-share' activity via the 'breakout rooms' feature on the 'Zoom' application enabled students to engage in intra-group and inter-group discussions. However, it was noteworthy that a teacher with low classroom interaction used this technique reluctantly. It was observed that another teacher, despite having low computer usage and technical problem-solving skills, was more enthusiastic. This highlights the importance of support that teachers receive during the process and collaboration with the researcher. It can be said that as teachers receive support and interact with the researcher, their confidence increases, and they carry out formative assessment practices more enthusiastically. Similarly, Gilson's (2009) study indicates that teachers value professional support and collaboration. Through this support, it was observed that teachers' confidence increased, and they conducted formative assessment practices more enthusiastically. A project study conducted by Harrison (2013) also supports similar results. It has been stated that collaboration between researchers and teachers provides formative feedback to teachers, and this feedback helps teachers make sense of and improve these practices. These findings parallel the results of the current study and indicate that when teachers are in constant communication and collaboration, they plan and implement formative assessment practices more effectively.

In this research, no self-assessment activities were encountered in the pre-implementation lesson observations of the three teachers, therefore it was determined that teachers were at the initial level in the self-assessment component. This finding is consistent with the findings of similar studies in the literature (İnaltun, 2019; Gotwals et al., 2015). In these studies, it was also found that teachers generally do not use self-assessment activities. However, in the current study, it was shown that teachers' reasons for not including self-assessment activities in their lessons were the inadequacy of lesson time and the difficulties they faced in implementing these activities in online learning environments. Additionally, it is a result of this study that students do not trust their own assessments in the self-assessment process and are accustomed to teacher-centered assessments. However, as the process progresses, it was observed that students become more confident in this process.

In similar studies in the literature (Gashi-Shatri & Zabeli, 2018; Harris & Brown, 2013; Yang et al., 2021), it has been emphasized that teachers need support in implementing self-assessment activities during the application process, and that time is crucial for students to understand this process. Additionally, DeNome (2015) has noted that factors such as school and environmental context, student academic achievement, and parents' socioeconomic status are influential in the self-assessment process. The findings of the current study are in line with the literature. Consequently, it has been stated in the current study that when teachers incorporate self-assessment activities along with success criteria, student engagement increases and this process enhances students' learning awareness.

In this study, it was found that teachers did not use the "peer assessment" component before the application, which is similar to the findings of other studies in the literature (Earle, 2014; Gotwals et al., 2015). The reasons for this could be attributed to teachers' lack of knowledge about using this component in online teaching and time constraints. In the current study, one of the participating teachers mentioned that peer assessment is the most important process of formative assessment. The teacher emphasized the importance of students accepting peer criticisms during this process. Additionally, in line with other studies in the literature (Anker-Hansen & Andrée, 2019; Gömleksiz & Ayhan, 2011), it was stated in the current study that peer assessment encourages critical feedback exchange among students and provides guidance among peers. Furthermore, in the current study, a teacher expressed reluctance to integrate this method into lessons due to a negative experience with peer assessment. This concern may be associated with the idea that students criticizing each other could be socially uncomfortable. Students' lack of trust in peer feedback and their tension during the process indicate doubts about reliability and validity. These findings highlight complex factors affecting teachers' and students' participation in peer assessment processes, such as teachers' previous experiences and students' social interactions and performance anxiety.

When examining teachers' formative assessment practices, it was observed that all three teachers were at the "effective" level in the "instructional decisions" component before the application. At this level, teachers used the information collected regarding student learning to shape instruction. This finding differs from the findings of a study conducted by Haug and Ødegaard (2015). In their study aiming to investigate how elementary school teachers support conceptual understanding within the formative assessment framework, it was found that teachers let the curriculum rather than student understanding decide when to move on to the next topic. The study also found that teachers lacked sufficient pedagogical content knowledge. Using data on student learning to shape instruction and taking action for the next step requires a certain level of pedagogical content knowledge (Bell, 2000). In this regard, in the current study, it can be said that collaborative work and support provided to teachers were effective. Preparatory work with teachers, training provided, and weekly planning and reflection meetings may have increased teachers' pedagogical content knowledge regarding formative assessment. In the current study, teachers needed to diversify the data collection methods used to gather information about student learning in order to reach the "expert" level. Diversifying data collection strategies may have also led to changes in the types of questions teachers used. This could have supported the development of the instructional decisions component. Gotwals et al. (2015) found a moderate to strong relationship among teachers' use of formative assessment components in their study. The study found that question types, feedback loops, and instructional decisions influenced each other. The findings of the current study are consistent with the findings of similar studies.

In this study, aimed at revealing the determination of teachers' use of formative assessment components and addressing the process of addressing identified deficiencies, the detailed discussion of the pre- and post-application change process of formative assessment components by teachers has been provided up to this point. In this process, various factors influencing the implementation of formative assessment have also been identified. Due to Covid-19, the current study being conducted in online environments has been expressed by teachers as the factor that most affected the process. Teachers have indicated various problems related to the use of formative assessment in online environments. These problems include lower student attendance in online environments compared to face-to-face settings, lack of technical equipment (internet, computer, tablet, etc.) required for students to attend classes online, and teachers' lack of experience in online education. In this regard, it is observed that the requirements in online learning environments are greater than those in face-to-face environments (Ingram et al., 2010; Kearsley & Blomeyer, 2004). Since interaction between teachers and students is more limited in online education environments compared to face-to-face educational settings, it becomes more crucial. Continuity of teacher-student interaction emphasizes the importance of feedback loops. Similarly, in a study by Popa et al. (2020), when the results of a study investigating the attitudes, perceptions, and understandings of university faculty members and students during online learning and teaching experiences during Covid-19 were examined, teacher-student interaction, timely feedback, and modifying or improving the pedagogical design of the course based on the outcomes of feedback were found to be the factors contributing to success in online learning environments. Hence, ensuring continuous student engagement in online learning environments is also important. In order to increase student participation, teachers need to be experienced in using strategies to ensure that students are active in online learning environments. The findings of the current study have revealed that teachers were inexperienced in online teaching practices before the implementation. Similarly, in a study conducted by Rehn et al. (2018) to identify the skills required by teachers providing online education, it was concluded that teachers were inadequate in terms of encouraging student interactions and the strategies they used in class. The findings in the literature are consistent with the current study. The reason for teachers' inexperience in online learning environments may be the lack of previous need to use this platform. As the strategies used to obtain information about student learning through formative assessment practices in online environments were shared with teachers and as teachers used these strategies, it was observed that teachers' control in online learning environments increased. Additionally, as teachers used self-assessment and peer assessment techniques in online learning environments, an increase in

student participation was observed. This finding is consistent with the findings of similar studies in the literature (Gikandi & Morrow, 2016; Sudakova et al., 2022; Veugen et al., 2022).

Based on the findings obtained from the study, factors generally affecting the use of formative assessment components by teachers can be stated as teachers' pedagogical beliefs and attitudes, collaboration and adequate support, time, experience, and centralized exams, teachers' educational understanding, and their use of online learning environments. When looking at the development of teachers' formative assessment components, it can be said that two teachers reached the expert level in all components and one teacher reached the expert level in all components except the peer assessment component (at the developing level).

RECOMMENDATIONS

In studies aimed at improving teachers' formative assessment practices, researchers are recommended to work collaboratively with teachers and actively participate in the process. The duration of the study lasted for one semester of the academic year. In studies to be conducted in this field, the duration can be extended. In the study, planning and reflection meetings with teachers were conducted by the researcher. For ease of implementation, in studies with a similar design to this study, appropriate planning can be made in advance, and teachers, researchers, and experts in the validation committee can hold meetings together. The professional experiences of the participating teachers in the study are 10 years and above. Comparisons can be made between the roles and implications of teachers who are new to the profession and those with 10 years and above of experience. The study was conducted with 5th and 7th-grade science teachers. Research can be conducted for other grades and subjects not studied. In the research results, it was found that implementing peer assessment in the classroom was more challenging compared to other components. Factors affecting the implementation of the peer assessment component in the classroom can be examined by conducting studies with both teachers and students. The study being conducted in online learning environments was generally perceived as a disadvantage by the participating teachers. A design for an experimental study can be created to examine the effect of online learning environments on teachers' use of formative assessment components in both face-to-face and online learning environments. Additionally, for teachers to acquire knowledge about formative assessment and to have the opportunity to implement it in their classrooms, the Ministry of National Education can include formative assessment practices in in-service training courses.

Declaration of Conflicting Interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The authors received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Examples of author contribution statements

Author 1 developed the research plan and theoretical framework under the guidance of Author 2. Author 2 provided continuous mentorship, offering critical feedback and making revisions throughout all stages of the study. Both authors collaboratively interpreted the findings and co-wrote the discussion and conclusion sections of the manuscript.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

Before recruitment could take place, ethics approval was obtained from the Kastamonu University (Protocol Number:2021/14).

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 389-400
doi: 10.24106/kefdergi.1683491

| Research Article / Araştırma Makalesi |

An Analysis of the Relationship between Disciplined Mind Characteristics and Entrepreneurial Tendencies of Primary School Fourth Grade Students*

İlkokul Dördüncü Sınıf Öğrencilerinin Disiplinli Zihin ve Girişimcilik Becerileri Arasındaki İlişkinin İncelenmesi

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Keywords
1.Disciplined mind
2.Entrepreneurship tendency
3.Primary school students

Anahtar Kelimeler
1.Disiplinli zihin
2.Girişimcilik eğilimi
3.İlkokul öğrencileri

Received/Başvuru Tarihi
08.03.2024

Accepted / Kabul Tarihi
24.04.2025

Abstract

Purpose: This study is to examine the relationship between disciplined mind characteristics and entrepreneurial tendencies of fourth grade primary school students.

*Design/Methodology/*Approach: The relational screening model was used as the method in the study. Data were collected using the Personal Information Form, "Disciplined Mind Scale", and "Entrepreneurship Tendencies Inventory". The research sample consisted of 576 fourth grade primary school students studying at state schools during the 2022-2023 school year.

Findings: As a result of simple and partial correlation analyses and simple linear regression analyses, a significant positive relationship was found between disciplined mind characteristics and entrepreneurial tendencies of fourth grade primary school students. In this significant relationship, it is necessary to work continuously to improve knowledge and skills. Gender, magazines read, TV programmes watched, computer games played, reading time, graduation status of parents, occupation status of parents are among the factors affecting the significant relationship.

Highlights: The study determined that the relationship between disciplined mind and entrepreneurial tendencies could be evaluated from primary school onwards, and that certain variables, including gender, family education level, and reading habits, had an effect on the situation.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, ilkokul dördüncü sınıf öğrencilerinin disiplinli zihin özellikleri ile girişimcilik eğilimleri arasındaki ilişkiyi incelemektir.

Materyal ve Yöntem: Çalışmada yöntem olarak ilişkisel tarama modeli kullanılmıştır.Veriler, Kişisel Bilgi Formu, "Disiplinli Zihin Ölçeği" ve "Girişimcilik Eğilimleri Envanteri" kullanılarak toplanmıştır. Araştırma örneklemini, 2022–2023 eğitim-öğretim yılında Afyonkarahisar İl merkezindeki devlet okullarında öğrenim gören 576 dördüncü sınıf öğrencisi oluşturmuştur.

Bulgular: Basit ve kısmi korelasyon analizleri ve basit doğrusal regresyon analizleri ile yapılan değerlendirmeler sonucunda, ilkokul dördüncü sınıf öğrencilerinin disiplinli zihin özellikleri ile girişimcilik eğilimleri arasında pozitif yönde anlamlı bir ilişki ortaya çıkmıştır. Bu anlamlı ilişkide cinsiyet, okunan dergi türü, izlenen TV programı, oynanan bilgisayar oyunları, kitap okuma süresi, anne ve baba eğitimi ile mesleki durum değişkenlerinin etkide bulunduğu tespit edilmiştir.

Önemli Vurgular: İlkokuldan itibaren disiplinli zihin ve girişimcilik becerisinin birlikte değerlendirilebileceği, cinsiyet, aile eğitim durumu, kitap okuma alışkanlığı gibi birtakım değişkenlerin duruma etki ettiği tespit edilmiştir.

* This study is derived from the master's thesis conducted by the first author under the supervision of the second author.

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Citation/Alıntı: Persenti, B., & Yazıcı, S. (2025). An Analysis of the Relationship between Disciplined Mind Characteristics and Entrepreneurial Tendencies of Primary School Fourth Grade Students, *Kastamonu Education Journal, 33*(2), 389-400. doi: 10.24106/kefdergi.1683491

INTRODUCTION

Knowledge is related to space and connections between disciplines. It is accepted that there is a direct relationship between learning and knowledge. Because newly learned information is connected with the old ones by learners to have new knowledge. This new knowledge is processed and made sense (Yılmaz, 2009). Since individuals' thinking styles are not the same depending on their mental processes, studies on these differences have gained importance. In order to synthesize knowledge, it is necessary to learn with new and different methods (Başaran, 2004). This situation paved the way for the formation of mental models.

Gardner (2007) identified five mind models that will build the future: disciplined mind, synthetic mind, creative mind, respectful mind and ethical mind. Disciplined mind, which is discussed in the study, refers to mastering one or more disciplines. Disciplines provide the mind with structured approaches to thinking (Charles, 2008). Gardner, who accepts disciplines as a different phenomenon, also defines the discipline as thinking about the world in a certain way. A person can achieve discipline to the extent that he acquires habits that will enable him to make continuous and endless progress in mastering a skill, profession or field of knowledge. A disciplined mind is a structure that knows that it is necessary to constantly work to develop knowledge and skills (Gardner, 2007).

In today's world where globalization dominates, working efficiently and being highly productive are of great importance. Increasing technological developments have affected entrepreneurial activities (Aytaç and İlhan, 2007). This situation increases the need for entrepreneurial individuals who constantly update themselves and improve themselves in more than one discipline. Entrepreneurship is a process in which opportunities are sought to produce value and various resources are combined to benefit from these opportunities (Özdevecioğlu and Cingöz, 2009). The Ministry of National Education (MONE) changed its educational approach in 2005 and aims to provide students with entrepreneurship skills (MONE, 2018). In this sense, entrepreneurship is a skill that enables an individual to turn his/her feelings and thoughts into action, to develop a plan and program to achieve the desired goals, to manage the activities, to be creative and innovative, to take risks and to achieve the goal (Figel, 2007).

Entrepreneurship at the primary school level includes skills that can be developed in the school environment, such as generating different ideas, evaluating opportunities, making innovative acts, having a desire to succeed, being brave and taking risks in achieving goals, being determined and persistent, and carrying out various projects and activities (Yurtseven, 2020). An entrepreneurial individual must have a mental structure where he can use more than one method together in order to develop and master his tendencies. Therefore, the individual's disciplined mental characteristics and entrepreneurial tendencies should be reconciled at the primary school level. There are studies on these topics, but these studies have not been carried on a sample of primary school subjects. Ocak and İçel (2023) studied the relationship between disciplined mind characteristics and steam attitudes, Sarıkaya (2022) studied the relationship between disciplined mind characteristics and scientific process skills, and Can Aran (2014) and Yılmaz (2012) studied the relationship between disciplined mind characteristics and science education. The following studies analtsed the relationship between entrepreneurial tendencies and other factors such as multiple intelligences (Kurtdede Fidan and Argıç 2023), steam attitude (Sarı 2022), attitudes (Sarı and Katrancı 2021), Fetemm attitudes is (Konuş 2019), the effect in terms of gender (Akman 2019), emotional intelligence (Akpınar and Alkış (2019), basic motivation sources (Özçoban and Özkul 2019), demographic variables (Salik and Kaygın 2016), factors affecting tendency (Ulucan 2015), and socio-demographic characteristics (Türkmen and İşbilir 2014). This topic was examined by Doğan (2013) on a sample of university students. Gardner (2007) states that the formation of a disciplined mind begins before adolescence and continues throughout one's life. Therefore, the 4th grade of primary school is an ideal period for determining the disciplined mental characteristics of students. Given that entrepreneurship skills, which are affected by more than one discipline, are included in the educational programs, it is thought that a study that will evaluate both concepts together will contribute to the existing knowledge on these topics.

This study aims to examine whether or not there is a relationship between the disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students in terms of various variables (Gender, parents' education level, parents' occupation, book reading time, type of magazines read, TV program watched, computer games). The research question of the study is as follows: "What is the relationship between the disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students?" The sub-research questions aimed to be answered based on this question are:

1) What is the relationship between the disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students?
2) What is the predictive factor in the relationship between disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students?
3) What is the effect of the variables gender, father's education level, mother's education level, parents' occupation, daily book reading time, type of magazines read, TV programs watched and computer game played on the relationship between the disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students?

METHOD/MATERIALS

This research is designed as a survey study which is part of the quantitative research methods. Quantitative research is defined as a positivist view that sees reality independently of the researcher and assumes that it will be observed and measured objectively (Büyüköztürk et. al., 2020; Hocaoğlu and Akkaş Baysal, 2019). Relational scanning, on the other hand, is a type of research that examines relationships and connections beyond describing situations or events (Büyüköztürk et. al., 2020). This type of research aims to determine whether or not there is a change between two or more variables and to what extent this change occurs (Karasar, 2005). The study examines whether or not there is a relationship between the disciplined mental characteristics and entrepreneurial tendencies of fourth grade primary school students and the variables of gender, parents' education level, parents' profession, book reading time, type of magazines read, TV programs watched, and computer games played.

Participants

This study targets the fourth grade students attending public schools in the central district of Afyonkarahisar during the 2022-2023 school year. The participants of the study were selected using the convenience sampling. In this type of sampling the researcher selects people who are easy to reach (Kılıç, 2013; Robson, 2017). The participants of the study were 576 fourth grade students. Of them, 280 were female and 296 male. Table 1 presents the demographical information about the participants.

Table 1. Demographical Information about the Participants

Demographical İnformation	Variables	n	%
Gender	Female	280	48.6
	Male	296	51.4
Magazines Mostly Read	Not Reading	346	60.1
	Bilim Çocuk	154	26.7
	TRT Çocuk	61	10.6
	Minik Çocuk	10	1.7
	Çamlıca Çocuk	5	0.9
Watched TV Shows	Cartoons	294	51
	TV series-movies	155	26.9
	Documentaries	61	10.6
	Sport	48	8.3
	Game programs	18	3.1
Computer Games Played	Not Playing	99	17.2
	Strategy	228	39.6
	Sport	83	14.4
	Target	74	12.8
	Competition	49	8.5
	Design	43	7.5
The Daily Time For Reading Books	Less than 1 Hour	331	57.5
	1-2 Hours	186	32.3
	3 Hours or more	59	10.2
Mother Education	Illiterate	7	1.2
	Primary School	128	22.2
	Secondary School	150	26
	High School	182	31.6
	University	100	17.4
	Graduate	9	1.6
Mother Occupation	Housewive	409	71
	Public	87	15.1
	Private Sector	40	6.9
	Self-Employed	40	6.9
Father Education	İlliterate	2	0.3
	Primary School	75	13
	Secondary School	117	20.3
	High School	226	39.2
	University	132	22.9
	Graduate	24	4.2
Father Occupation	Private Sector	169	29.3
	Public	126	21.9
	Worker	108	18.8
	Self-Employed	173	30

As can be seen in Table 1 the rate of female students is 48.6% and that of male students is 51.4%. The magazines mostly read by the participants are found as follows: *Bilim Çocuk* magazine (26.7%), *TRT Çocuk* magazine (10.6%), *Minik Çocuk* magazine

(1.7%), and *Çamlıca Çocuk* magazine (0.9%). On the other hand, 60.1% of the participants reported that they did not read any children's magazines. The most watched TV shows by the participants are as follows: cartoons (51%), TV series-movies (26.9%), documentaries (10.6%), sports programs (8.3%), game programs (3.1%). The computer games played by the participants are as follows: 39.6% strategy games, 14.4% sports games, 12.8% target games, 8.5% competition games, and 7.5% design games. On the other hand, 17.2% of the participants reported that they never played computer games. The daily time for reading books among the participants is as follows: the rate of students who read books for less than 1 hour was 57.5%, the rate of students who read books for 1 hour to 2 hours was 32.3%, and the rate of students who read books for 2 hours or more was 10.2%. As can be seen in Table 1 31.6% of the students' mothers are high school graduates, 26% are secondary school graduates, 22.2% are primary school graduates, 17.4% are university graduates, 1.6% are graduate graduates and 1.2 of them illiterate. It is found that 71% of the students' mothers were housewives, 15.1% were public employees, 6.9% were self-employed and 6.9% were private sector employees. It is found that 39.2% of the students' fathers were high school graduates, 22.9% university graduates, 20.3% secondary school graduates, 13% primary school graduates, 4.2% postgraduate graduates and 0.3% illiterate. It is seen that 30% of the students' fathers are self-employed, 29.3% are private sector employees, 21.9% are public employees and 18.8% are workers. It is seen that most of the parents are high school graduates. In terms of occupational status, it is seen that the majority of mothers (71%) are housewives and the majority of fathers (30%) are self-employed.

Data Collection Tool

The data of the study were collected using the "Personal Information Form" developed by the author, the "Disciplined Mind Scale" developed by Ocak and İçel (2020) and the "Entrepreneurial Tendencies Inventory" developed by Yurtseven and Ergün (2018). A permission to collect the data was obtained from Afyon Kocatepe University Scientific Research and Publication Ethics Committee.

To check the reliability of the data collection tools, a pilot study was conducted with a sample of 40 students attending a public primary school. As a result of the analysis of the findings from the pilot study the Cronbach Alpha reliability of the Disciplined Mind scale was found to be .80. The Cronbach Alpha reliability of the Entrepreneurial Tendencies Inventory was determined as .86. In in social sciences studies, the lower limit of reliability is accepted as .70 (Şencan, 2005).

The study was carried out in six schools. The school principals were informed about the implementation process.

Data Analysis

The data collected from the data collection tools were analysed using the statistical methods. The data obtained from the students were transferred to the computer. The demographical characteristics of the participants and their parents were analysed through the descriptive statistics using the arithmetic mean, standard deviation, percentage and frequency..

A normality test was performed to determine the distribution of the data (Miran, 2021). The skewness and kurtosis between -1.0 and +1.0 is considered to be a reflection of the normal distribution (Büyüköztürk, Çokluk & Köklü, 2011). The results showed that the data were normally distributed, since the Skewness-kurtosis values were found to be between -1.0 and +1.0. The skewness and kurtosis data of the scales are shown in Table 2.

Table 2. Skewness-Kurtosis Values of the Disciplined Mind Scale and Entrepreneurial

Variables	Article	N	$\bar{X}$	sd	Skewnes	Kurtosis	Kolmogorov-Smirnov
DMS Total	27	576	4.05	.018	-.364	-.089	.000
ETI Total	24	576	4.08	.023	-.613	-.043	.000

Tendencies Inventory

The linear relationship between two or more variables is called correlation. The amount of relationship between variables is calculated with a correlation technique called binary or simple correlation (Köklü et al., 2006). The simple correlation analysis was conducted to determine the relationship between the Disciplined Mind Scale scores and the Entrepreneurial Tendencies Inventory scores. Since the distribution was found to be normal in the study, the Pearson Correlation coefficients were examined. The simple linear regression analysis was conducted to determine the predictor in the relationship between the Disciplined Mind Scale and the Entrepreneurial Tendencies Inventory. The simple and partial correlation analyses were used to determine whether or not the relationship between Disciplined Mind Scale scores and Entrepreneurial Tendencies Inventory scores differed based on the variables. The score ranges of the answers given by the students are as follows: 4.21-5.00 "Always", 3.41-4.20 "Most of the time", 2.61-3.40 "Sometimes", 1.81-2.60 "Rarely", and 1.00-1.80 "Never". in Table 2.

FINDINGS

In this part, the statistical analyses and findings obtained from the Disciplined Mind Scale and Entrepreneurial Tendencies Inventory are discussed.

The Pearson correlation analysis was performed to determine the relationship between the disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students, and the results of the analysis are shown in Table 3.

Table 3. Pearson Correlation Analysis on the Relationship between Disciplined Mind Characteristics and Entrepreneurial Tendencies of Primary School Fourth Grade Students

Factors	1	2	3	4	5	6	7	8	9	10	11
Disciplined Mind Scale (1)	1	.664**	.625**	.567**	.560**	.427**	.777**	.607**	.687**	.691**	.466**
Entrepreneurial Tendencies Inventory (2)		1	.840**	.847**	.848**	.758**	.578**	.271**	.506**	.481**	.425**
Being Successful (3)			1	.665**	.600**	.493**	.524**	.288**	.534**	.365**	.488**
Problem Solving (4)				1	.612**	.497**	.495**	.270**	.389**	.397**	.356**
Innovation (5)					1	.555**	.483**	.207**	.424**	.454**	.302**
Self-Confidence (6)						1	.397**	.120**	.312**	.365**	.249**
Thinking Like a Scientist (7)							1	.210**	.469**	.491**	.256**
Establishing Interdisciplinary Connections (8)								1	.192**	.123**	.247**
Motivation to Live Disciplined (9)									1	.388**	.443**
Deep Learning (10)										1	.175**
Connecting to Daily Life (11)											1

Table 3 shows that there is a statistically significant correlation between the scores of the Disciplined Mind Scale (DMS) and the scores of the Entrepreneurial Tendencies Inventory (ETI) (r=.664**, p<.01). All subscales of these tools are significantly correlated (p<.01). It is found that the strongest correlation was between the "Being Successful" factor and the "Problem Solving" factor (r= .665**, p<.01), and the weakest correlation is found to be between the "Self-Confidence" factor and the "Establishing Interdisciplinary Connections" dimensions (*r*= .120**, *p*<.01).

A simple linear regression analysis was conducted to determine the predictor of the relationship between disciplined mind characteristics and entrepreneurial tendencies, and the results of the analysis are shown in Table 4.

Table 4. Results of Simple Linear Regression Analysis to Determine the Predictor of the Relationship Between the Disciplined Mind Scale and the Entrepreneurial Tendencies Inventory

	B	Std. Error	(ß)	T	p	R	R^2	F	p
(Constant)	.594	.165		3.600	.000	.664	.441	452.487	. 000*
DMS Average	.860	.040	.664	21.272	.000				

As can be seen in Table 4 there is a statistically significant correlation disciplined mind characteristics and entrepreneurial tendencies since the significance level is at p<.05. It has been observed that disciplined mental characteristics have a positive and moderately significant effect on entrepreneurial tendencies. R^2 value was found to be .441 (R=.664; R^2 = .441, P<.05). Therefore, disciplined mind characteristics explain 44.1% of the change in the entrepreneurial tendencies variable.

A partial correlation analysis was conducted to examine the relationship between the disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on gender, and the results of the analysis are given in Table 5.

Table 5. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on Gender

Gender		N	$\bar{X}$	Sd	R	p
Female	DMS	280	4.11	.404	.709**	.000
	ETI		4.12	.551		
Male	DMS	296	4.00	.452	.625**	.000
	ETI		4.04	.566		

Table 5 indicates that there is a statsitically significant correlation between female participants' the DMS scores and their ETI scores ($r_{partial}$= .709, p= .00). There is also a positive and medium-level significant correlation between male participants' the DMS scores and their ETI scores ($r_{partial}$= .625, p= .00).

A partial correlation analysis was conducted to examine the relationship between disciplined mind characteristics and entrepreneurial tendencies of the fourth grade primary school students based on their fathers' education level, and the results of the analysis are given in Table 6.

Table 6. Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on Father's Educational Level

Father Education		N	$\bar{X}$	Sd	R	p
Illiterate	DMS	2	4.14	.052		
	ETI		4.25	.648		
Primary School	DMS	75	4.00	.419	.613	.000
	ETI		4.03	.574		

Secondary School	DMS	117	3.97	.390	.605	.000
	ETI		3.99	.557		
High School	DMS	226	4.05	.426	.653	.000
	ETI		4.06	.567		
University	DMS	132	4.16	.466	.729	.000
	ETI		4.19	.527		
Graduate	DMS	24	4.04	.455	.742	.000
	ETI		4.16	.568		

As can be seen in Table 6 the correlation between the DMS scores and the ETI scores of the participants whose fathers were primary school graduates (r=.613, p<.01), secondary school graduates (r=.605, p<.01) and high school graduates (r=.653, p<.01) are found to be positively and moderately significant. The correlation between the DMS scores and the ETI scores of the participants whose fathers were university graduates (r=.729, p<.01) and postgraduate education graduates (r=.742, p<.01) was found to be positively and highly significant.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the mothers' education level, and the results of the analysis are given in Table 7.

Table 7. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on Mother's Educational Level

Mother Education		N	$\bar{X}$	Sd	R	p
Illiterate	DMS	7	3.88	.338	.812	.026
	ETI		3.79	.486		
Primary School	DMS	128	4.00	.405	.558	.000
	ETI		4.04	.521		
Secondary School	DMS	150	4.03	.420	.642	.000
	ETI		4.04	.539		
High School	DMS	74	4.05	.451	.707	.000
	ETI		3.05	.607		
University	DMS	100	4.18	.430	.672	.000
	ETI		4.25	.529		
Graduate	DMS	9	3.96	.495	.784	.012
	ETI		3.95	.542		

As can be seen in Table 7 the correlation between the DMS scores and the ETI scores of the participants whose mothers are primary school graduates (r=.558, p<.01), secondary school graduates (r=.642, p<.01), and university graduates (r=.672, p<.01) is positively and medium-level significant. The correlation between the DMS scores and the ETI scores of the participants whose mothers are illiterate (r=.812, p<.05), high school graduate (r=.707, p<.01), postgraduate education graduate (r=.784, p<.05) is found to be positive and highly significant.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the fathers' occupation, and the results of the analysis are given in Table 8.

Table 8. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on Fathers' Occupation

Father Occupation		N	$\bar{X}$	Sd	R	p
Self-Employed	DMS	173	4.03	.452	.697	.000
	ETI		4.05	.614		
Public	DMS	126	4.14	.449	.704	.000
	ETI		4.19	.515		
Private Sector	DMS	169	4.04	.394	.620	.000
	ETI		4.05	.552		
Worker	DMS	108	3.99	.424	.605	.000
	ETI		4.03	.519		

Table 8 shows that the correlation between the DMS scores and the ETI scores of the participants whose fathers are self-employed (r=.697, p<.01), employed in private sector (r=.620, p<.01), and workers (r=.605, p<.01) is found to be positively and medium-level significant. The correlation between the DMS scores and the ETI scores of the participants whose fathers are employed in public sector (r=.704, p<.01) is found to be positively and highly significant.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the mothers' occupation, and the results of the analysis are given in Table 9.

Table 9. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on Mothers' Occupation

Mother Occupation		N	$\bar{X}$	Sd	R	p
Housewive	DMS	409	4.04	.425	.657	.000
	ETI		4.06	.554		
Public	DMS	87	4.17	.437	.662	.000
	ETI		4.23	.526		
Private Sector	DMS	40	4.03	.398	.465	.002
	ETI		4.01	.527		
Self-Employed	DMS	40	3.95	.486	.797	.000
	ETI		3.96	.669		

Table 9 shows that the correlation between the DMS scores and the ETI scores of the participants whose mothers are housewives (r=.657, p<.01), are employed in public sector (r=.662, p<.01), and employed in private sector (r=.465, p<.01) are found to be postive and significant at medium level. The correlation between the DMS scores and the ETI scores of the participants whose mothers are self-employed is found to be positively and highly significant (r=.797, p<.01).

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the participants' daily reading books, and the results of the analysis are given in Table 10.

Table 10. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on the participants' daily reading boks

Book reading time		N	$\bar{X}$	Sd	R	p
Less Than 1 Hour	DMS	331	3.99	.433	.625	.000
	ETI		4.03	.560		
1 Hour to 2 Hours	DMS	186	4.15	.391	.666	.000
	ETI		4.13	.542		
2 Hours or More	DMS	59	4.10	.491	.828	.000
	ETI		4.19	.593		

Table 10 shows that the correlation between the DMS scores and the ETI scores of the participants who read books 0-1 hour daily (r=.625, p<.01), and those who read books 1-2 hours daily (r=.666, p<.01) is found to be positive and significant at medium level. The correlation between the DMS scores and the ETI scores of the participants who read books more than 2 hours daily (r=.828, p<.01) is found to be positively and highly significant.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the types of magazines read by the participants, and the results of the analysis are given in Table 11.

Table 11. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on the types of magazines read by the participants

Magazines Mostly Read		N	$\bar{X}$	Sd	R	p
Not Reading	DMS	346	3.98	.428	.634	.000
	ETI		3.98	.576		
Bilim Çocuk	DMS	154	4.23	.396	.673	.000
	ETI		4.30	.475		
TRT Çocuk	DMS	61	4.02	.434	.618	.000
	ETI		4.12	.526		
Minik Çocuk	DMS	10	4.01	.403	.828	.003
	ETI		4.07	.533		
Çamlıca Çocuk	DMS	5	4.07	.256	.583	.302
	ETI		3.88	.378		

As can be seen in Table 11 the correlation between the DMS scores and the ETI scores of the participants who read Bilim Çocuk magazine (r=.673, p<.01), who read TRT Çocuk magazine (r=.618, p<.01) is found to be positive and significant at medium level. The correlation between the DMS scores and the ETI scores of the participants who read Minik Çocuk magazine (r=.828, p<.01) is found to be positively and highly significant is found to be positively and highly significant. The correlation between the

DMS scores and the ETI scores of the participants who do not read any magazine (r=.634, p<.01) is also found to be positive and significant at medium level.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the types of TV shows watched by the participants, and the results of the analysis are given in Table 12.

Table 12. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on the types of TV shows watched by the participants

Watched TV Shows		N	$\bar{X}$	Sd	R	p
Cartoons	DMS	294	4.05	.434	.652	.000
	ETI		4.08	.548		
TV series- movies	DMS	155	4.00	.429	.707	.000
	ETI		4.00	.602		
Documentaries	DMS	61	4.20	.363	.738	.000
	ETI		4.24	.463		
Sport	DMS	48	4.02	.480	.562	.000
	ETI		4.14	.513		
Game programs	DMS	18	4.05	.430	.532	.023
	ETI		4.05	.693		

Table 12 indicates that the correlation between the DMS scores and the ETI scores of the participants who watch cartoons (r=.652, p<.01), sports programmes (r=.562, p<.01), and who watch quiz programs (r=.532, p<.05) is found to be positive and significant at medium level. The correlation between the DMS scores and the ETI scores of the participants who watch documentary (r=.738, p<.01) and those who television series (r=.707, p<.01) is found to be positively and highly significant.

A partial correlation analysis was conducted to examine the relationship between disciplined mental characteristics and entrepreneurial tendencies of the fourth grade primary school students based on the types of computer games played by the participants, and the results of the analysis are given in Table 13.

Table 13. The Relationship Between Disciplined Mind Scale and Entrepreneurial Tendencies based on the types of computer games played by the participants

Computer Games		N	$\bar{X}$	Sd	R	p
Strategy Content	DMS	228	4.07	.453	.711	.000
	ETI		4.07	.580		
Not playing	DMS	99	4.10	.386	.665	.000
	ETI		4.10	.567		
Sports Content	DMS	83	4.02	.469	.565	.000
	ETI		4.15	.516		
Target Content	DMS	74	3.98	.409	.671	.000
	ETI		3.92	.580		
Race Content	DMS	49	4.04	.435	.738	.000
	ETI		4.04	.561		
Design Content	DMS	43	4.06	.383	.523	.000
	ETI		4.25	.406		

Indicates that the correlation between the DMS scores and the ETI scores of the participants who do not play computer games (r=.665, p<.01), those who play sports games (r=.565, p<.01), those who play target games (r=.671, p<.01), and those who play design games (r=.523, p<.01) is found to be positive and significant at medium level. The correlation between the DMS scores and the ETI scores of the participants who play strategy games (r=.711, p<.01) and those who play competitive games (r=.738, p<.01) is found to be positively and highly significant.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study it is found that there is a significant and positive relationship between Disciplined Mind Characteristics and Entrepreneurial Tendencies of the fourth grade primary school students. A positive and significant relationship was found between the dimensions and factors of both scales. The strongest correlation was found to be between the Achievement factor and the Problem Solving factor, while the weakest correlation was found to be between the Self-Confidence factor and the Making Interdisciplinary Connections dimension. In a similar study conducted by Argıç (2022) with the fourth grade primary

school students, the strongest correlation was found between being successful and problem solving factors. Considering that problem solving skills are among the skills required for a person to manage his life successfully, individuals must have the skill of solving the problems in order to live a life in which they can make their own decisions and live successfully (Çolpan Kuru, 2021).

It is found in the study that the disciplined mental characteristics of the fourth grade primary school students had a positive and moderately significant effect on their entrepreneurial tendencies. It is concluded that 44.1% of the change in their entrepreneurial tendencies was explained by their disciplined mind characteristics. In the study conducted by Argıç (2022), it is reported that multiple intelligence domains had a positive and moderately significant effect on the entrepreneurial tendencies of the students, and that the multiple intelligence domains explained 56.7% of the change in the entrepreneurial tendencies.

A positive and high level relationship was determined between female students' DSI scores and ETI scores. A positive and moderately significant relationship was determined between male students' DSI scores and ETI scores. It is understood that the relationship between the disciplined mental characteristics and entrepreneurial tendencies of female students is higher than that of male students. In the study conducted by Kurtdede Fidan and Argıç (2023), a significant difference was found in the entrepreneurship tendencies of the fourth grade primary school students in favor of girls. Argıç (2022) found a positive and high level relationship between multiple intelligences and entrepreneurial tendencies of both male and female students. In Yurtseven's (2020) study, the students' entrepreneurial tendencies did not show a significant difference according to the gender variable. In the study conducted by Sarıkaya (2022), a positive, low-level significant relationship was detected between the scientific process skills and disciplined mind characteristics of female students, and it was concluded that this relationship was not significant among male students.

In this study, a positive and moderate relationship was found between the DSI scores and ETI scores of the fourth grade primary school students whose fathers were primary school graduates, secondary school graduates and high school graduates. A positive and highly significant relationship was found between the DSI scores and ETI scores of those whose fathers had university or postgraduate degrees. Therefore, fathers' educational background has important effects on the relationship between students' disciplined mental characteristics and entrepreneurial tendencies. It seems that this relationship becomes more positive as the education level of the fathers increases. In his study, Sarıkaya (2022) found that fathers' educational background had a positive, but low-level significant effect on the relationship between students' scientific process skills and disciplined mind characteristics.

In this study, it is found that there was a positive and moderate relationship between the DSI scores and ETI scores of the fourth grade primary school students whose mothers were primary school graduates, secondary school graduates and university graduates. A positive and highly significant relationship was found between the DSI scores and ETI scores of the students whose mothers were illiterate or whose mothers were high school or graduate graduates. Therefore, the educational background of mothers affects the relationship between students' disciplined mental characteristics and their entrepreneurial skills. However, this effect is not statistically significant. A similar result was reported in the study conducted by Sarıkaya (2022). In the study, a positive, low-level significant relationship was detected between the scientific process skills and disciplined mind characteristics of the students whose mothers were primary school graduates, secondary school graduates and high school graduates, while no significant relationship was detected between the scientific process skills and disciplined mind characteristics of the students whose mothers were university or postgraduate graduates.

In this study, a positive and moderate relationship was found between the DSI scores and the ETI scores of the fourth grade primary school students whose fathers were self-employed, were private sector employees or were workers. A positive and highly significant relationship was determined between the DSI scores and ETI scores of the students whose fathers are public employees. Therefore, it seems that fathers' profession has a positive effect on the relationship between students' disciplined mental characteristics and their entrepreneurial skills. However, different professions have different effects on this relationship. İçel (2019) found a moderate positive relationship between the disciplined mental characteristics and STEM attitudes of the fourth grade primary school students based on fathers' profession.

In this study, a positive and moderate relationship was found between the DSI scores and ETI scores of the fourth grade primary school students whose mothers were housewives and those whose mothers were employed in the public or private sector. A positive and highly significant relationship was detected between the DSI scores and ETI scores of those whose mothers were self-employed. Therefore, mothers' profession creates a positive relationship between students' disciplined mental characteristics and their entrepreneurial skills. On the other hand, different professions have different effects on this relationship.

In this study, it is found that there was a positive and moderate relationship between the DSI scores and ETI scores of the fourth grade primary school students whose daily book reading time was between 0-1 hour and 1-2 hours. It is also found that the relationship between the DSI scores and ETI scores of the students who read books for more than 2 hours daily was positive and high. Therefore, daily book reading time positively affects the relationship between the students' DSI scores and ETI scores. It is seen that this effect reaches a higher level as the time spent reading books increases. In the study with the fourth grade primary school students, Sarı (2022) found that the students' entrepreneurship tendency differed significantly depending on the number of books they read in a month.

In this study, it is found that there was a positive and moderate relationship between the DSI scores and ETI scores of the students who did not read any magazines and students who read Bilim Çocuk and TRT Çocuk magazines. A positive and highly significant relationship was determined between the DSI scores and ETI scores of the fourth grade primary school students who read Minika Çocuk magazine. Therefore, reading magazines has an impact on the relationship between the DSI scores and ETI scores of the fourth grade primary school students. İçel (2019) found a moderate positive relationship between students' disciplined mind characteristics and the STEM attitudes, depending on their magazine subscription status. In the study conducted by Sarı (2022), it was found that regularly read children's magazines had clear effects on students' entrepreneurship tendency, and science-themed children's magazines made a significant contribution to the students' entrepreneurship tendency. However, it is noteworthy that there is a positive relationship between the DSI scores and ETI scores of the fourth grade primary school students who do not read magazines.

In this study, a positive and moderate relationship was found between the DSI scores and ETI scores of the fourth grade primary school students who watched television programs such as cartoons, sports and game shows. For those who watch documentaries and TV series and movies, this relationship is positive and at a high level. In the study by Sarıkaya (2022) it is found that there is a low-level positive relationship between the scientific process skills and disciplined mind characteristics of the students who watched TV for less than 2 hours per day. Therefore, it shows that the type of TV programs watched may have a positive relationship on students' DSI scores and ETI scores, and that documentaries and television series can make more contribution in this regard. However, television viewing time also needs to be taken into account.

The correlation between the DSI scores and ETI scores of the fourth grade primary school students who do not play computer games and those who play computer games with sports content, target content and design content are positive and moderate. A positive and highly significant relationship was found for those who played computer games with strategy content and competitive content. This shows that computer games with strategy content and competitive content can make a higher contribution between students' DSI scores and ETI scores.

The following recommendations are made depending on the results of the study:

In this study is limited to the findings from the fourth grade students in Afyonkarahisar province. The selection of participants from other parts of Turkey would allow to make generalizations.

The study was conducted using variables such as gender, magazine types, TV programs, computer games, parents' profession, and parents' education level. Future studies may look at the effects of other variables.

Considering the positive relationship between students' disciplined mind characteristics and entrepreneurial tendencies, in-class activities that develop disciplined mind characteristics and entrepreneurial tendencies can be developed.

Gaining the habit of reading books and magazines will positively affect the students' disciplined mind characteristics and entrepreneurial tendencies. Therefore, their acquisition of these habits can have a positive impact on their lives.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding

The authors received no financial support for the research, author-ship, and publication of this article.

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Author contribution statements

B.P. and S.Y. conceived of the presented idea. B. P. developed the theory and performed the computations. B.P. and S.Y. verified the analyses. S.Y. supervised the findings of the study. All authors discussed the results and contributed to the final manuscript.

Ethics Committee Approval Information

Ethical approval for the study was granted by Afyon Kocatepe University Ethics Committee (25.11.2022/ 2022-338) and Afyon Directorate of National Education (02.01.2023/E-70813604-100-151695).

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 401-410
doi: 10.24106/kefdergi.1683517

| Research Article / Araştırma Makalesi|

Preparing Teachers for a ChatGPT-Influenced Workforce

Öğretmenleri ChatGPT'den Etkilenen İşgücüne Hazırlamak

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Keywords
1.Higher Education
2.Artificial Intelligence
3.AI literacy
4.Teacher Training
5.Digital Transformation

Anahtar Kelimeler
1.Yükseköğretim
2.Yapay Zekâ
3.YZ Okuryazarlığı
4.Öğretmen Eğitimi
5.Dijital Dönüşüm

Received/Başvuru Tarihi
01.10.2024

Accepted / Kabul Tarihi
20.04.2025

Abstract

Purpose: *In the 21st century, unique changes have become apparent in our lives. These changes have affected numerous fields, and education is no exception. Innovations in education have progressed rapidly, particularly with the prevalence of Artificial Intelligence (AI) applications. Higher education institutions play a crucial role in these developments due to their capacity to shape professional competencies and raise societal awareness. This study discusses the impact of AI applications on higher education and their significance in teacher training.*

Design/Methodology/Approach: *The study explores AI applications in higher education, particularly in preparing prospective teachers for AI-driven work environments. A review of literature and current educational practices was conducted to assess the integration of AI into teacher training programs. The study focuses on AI literacy, curriculum adaptation, and professional development.*

Findings: *AI applications have started to transform higher education by enhancing pedagogical methods, improving access to educational resources, and redefining the skill sets required for future educators. However, there remains a gap in AI literacy among pre-service teachers. Higher education institutions must incorporate AI-based courses and digital competencies to prepare teachers effectively.*

Highlights: *The study emphasizes the need for AI literacy in teacher training programs to ensure future educators can effectively utilize AI technologies in their profession. Recommendations include updating curricula, integrating AI-driven tools, and fostering interdisciplinary collaboration in higher education.*

Öz

Çalışmanın Amacı: *21. yüzyılda yaşamımızda önemli değişimler meydana gelmiştir. Bu değişimler birçok alanı etkilediği gibi, eğitim alanında da önemli dönüşümler yaşanmıştır. Yapay zekâ uygulamalarının yaygınlaşmasıyla birlikte, eğitimde inovasyon hız kazanmıştır. Yükseköğretim kurumları, profesyonel becerileri şekillendirme ve toplumsal farkındalık oluşturma konularında kritik bir rol üstlenmektedir. Bu çalışma, yükseköğretimde yapay zekâ uygulamalarının etkisini ve öğretmen eğitimi açısından önemini ele almaktadır.*

Materyal ve Yöntem: *Çalışmada, yükseköğretimde yapay zekâ uygulamalarının öğretmen yetiştirme sürecine entegrasyonu incelenmiştir. Literatür taraması ve mevcut eğitim uygulamalarının analizi yapılarak, öğretmen adaylarını yapay zekâ destekli bir iş gücüne hazırlamak için gerekli stratejiler değerlendirilmiştir. Yapay zekâ okuryazarlığı, müfredat adaptasyonu ve mesleki gelişim odak noktaları olarak ele alınmıştır.*

Bulgular: *Yapay zekâ uygulamaları, yükseköğretimde pedagojik yöntemleri geliştirerek, eğitim kaynaklarına erişimi artırarak ve öğretmenlerin sahip olması gereken becerileri yeniden tanımlayarak önemli bir dönüşüm sağlamaktadır. Ancak, öğretmen adayları arasında yapay zekâ okuryazarlığı konusunda hala eksiklikler bulunmaktadır. Yükseköğretim kurumlarının, öğretmenleri daha etkin bir şekilde hazırlayabilmesi için yapay zekâ temelli dersleri ve dijital yeterlilikleri müfredata dahil etmesi gerekmektedir.*

Önemli Vurgular: *Çalışma, öğretmen eğitimi programlarında yapay zekâ okuryazarlığının gerekliliğini vurgulamaktadır. Geleceğin eğitimcilerinin yapay zekâ teknolojilerini etkin bir şekilde kullanabilmesi için müfredatın güncellenmesi, yapay zekâ destekli araçların entegrasyonu ve disiplinler arası iş birliğinin teşvik edilmesi önerilmektedir.*

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Citation/Alıntı: Helvacı, İ. (2025). Preparing Teachers for a ChatGPT-Influenced Workforce, *Kastamonu Education Journal, 33*(2),401-410. doi:10.24106/kefdergi.1683517

INTRODUCTION

In the 21st century, unprecedented changes have occurred in professional and personal lives (Davenport & Ronanki, 2018). These have affected numerous trajectories such as health, transport, and tourism, as well as spheres of education. Innovations in education have been progressing rapidly in recent years in particular with the advent of artificial intelligence (AI) applications. Whilst artificial intelligence applications continue to progress without slowing down, higher education institutions are gaining a special importance in their competence in guiding the said processes (Southworth, et al., 2023). This is on account of the fact that higher education institutions offer through which professional skills and competencies are acquired. Further to this, teacher training and many other professions that shape society are carried out through programs in higher education institutions (Leander & Burriss, 2020). From this perspective, it would be fair to say that higher education institutions are uniquely positioned to raise societal awareness. Due to their sui generis being, higher education institutions, need to be constantly kept up-to-date (Robinson, 2020) since as long as higher education institutions remain up-to-date, individuals will be able to respond more quickly to the needs of the dynamics of this changing world. In this regard, artificial intelligence applications, which have come to the fore recently, should be taken into consideration by the relevant stakeholders (Kandlhofer et al., 2016).

Prior to ensuring the implementation of artificial intelligence applications in higher education, artificial intelligence literacy should be gained by the related agents (Luckin et al., 2022). As a matter of fact, artificial intelligence is no longer just an imaginary product created from science fiction. It is becoming an indispensable part of our lives that is progressing daily (Wong et al., 2020). For this very reason, individuals who have graduated from higher education should have developed sufficient literacy in artificial intelligence (Cantú-Ortiz et al., 2020). That said, even though artificial intelligence applications have started to be widely used worldwide, they have not yet attained the desired prevalence at the higher education level (Vincent-Lancrin & Van der Vlies, 2020). A line of literature points to that artificial intelligence applications are not sufficiently included in the curriculum of both undergraduate and graduating students (Cantú-Ortiz et al., 2020; Dai et al., 2020; Southworth, et al., 2023). At the same time, in the studies conducted by educational researchers, it is italicized that artificial intelligence literacy is indeed a skill that must be acquired during higher education (Ng et al., 2021; Su et al., 2022).

In this direction, it would be a positive step to involve artificial intelligence applications in higher education programs and hence curricula (Dai et al., 2020). Merely in this way can it be assured that higher education graduates have the adequate knowledge along with skills in the age of technology. Artificial intelligence literacy to be gained in higher education will help prepare learners in a more qualified way for their future viz. for the real life outside and professional lives (Long & Megerko, 2020; Rodríguez-García et al., 2021). The dimensions of artificial intelligence literacy prepared by Ng et al. (2021, p.5) according to Bloom's taxonomy, which should be acquired in higher education, are presented in Figure 1 below.

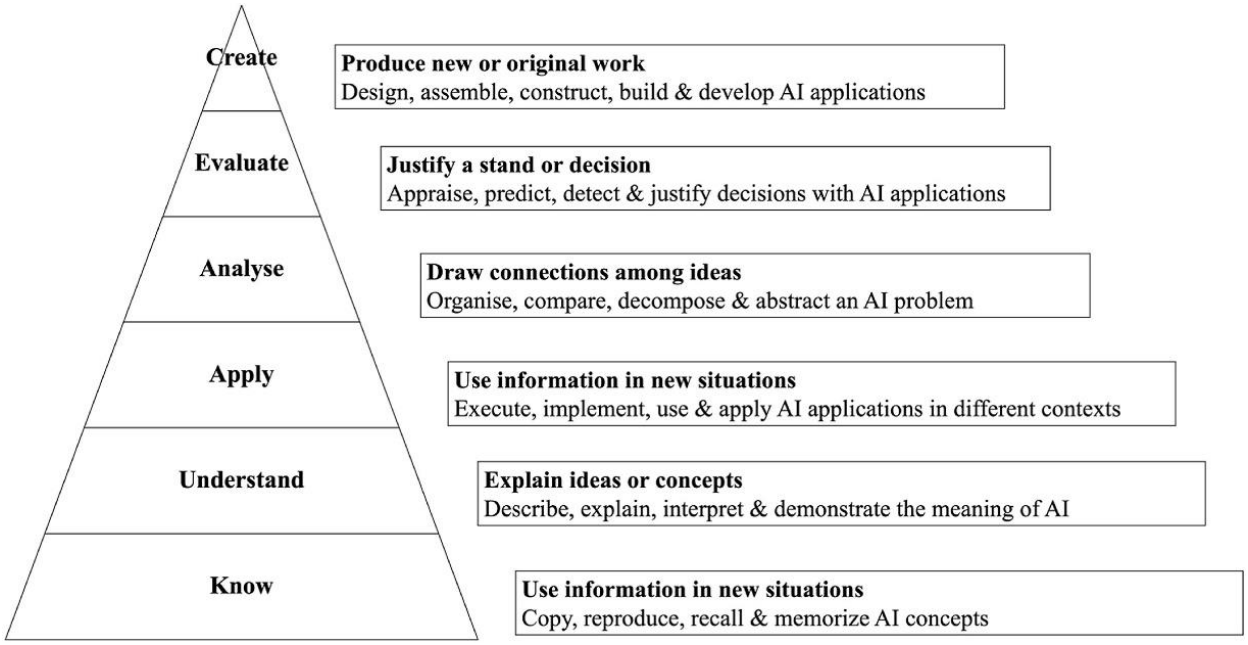

Figure 1. Artificial intelligence literacy and Bloom's taxonomy dimensions

Apparently, the skills become more complex from bottom to top. This hints at the fact that skill competence develops from the bottom to the top of the pyramid. It is noteworthy that in today's world of digital transformation, plentiful skills have started to be directly and indirectly associated with artificial intelligence applications. This realm has brought along the adaptation of artificial intelligence literacy to whatever is encountered in daily life and thereupon in the overcoming of problems. To this end, artificial intelligence literacy in higher education should be examined within the framework of TPACK (Koehler et al., 2013). In this respect, the application framework by Ng et al. (2021, p.5) is given in Figure 2.

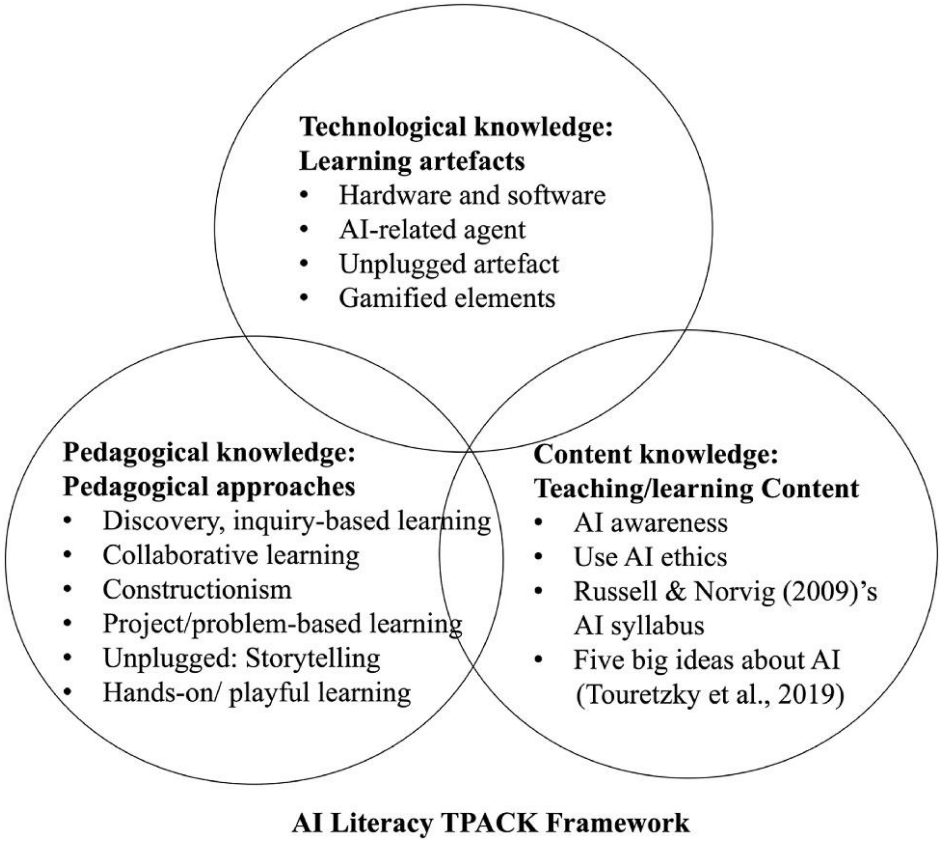

Figure 2. Artificial intelligence literacy and TPACK framework

It seems that artificial intelligence literacy at higher education level is effective in the fields of software, hardware, and gamification within the framework of technological knowledge. Within the framework of pedagogical knowledge, it mainly supports individuals in terms of the methods and techniques.

When the domain knowledge is scrutinized, one can comfortably state that it contributes to students in artificial intelligence awareness, ethical usage framework, course content creation and the creation of big ideas. These advantages provided by artificial intelligence literacy in higher education are especially important in the teacher training process and in warranting teachers start their professional lives in an equipped fashion.

A Review of the Literature - Why resort to Artificial Intelligence in Higher Education?

Artificial intelligence applications were first used in tasks such as data analysis, image identification and natural language processing after the year 2000 (Ahmad, 2019). Over time, these applications have continued to be in use with the development of technological applications, the production of autonomous vehicles, the creation of smart homes and devices, and the realization of digital applications that work with voice commands (Corwin et al., 2017). Today, artificial intelligence applications can be encountered in innumerable ways (Hu et al., 2019). According to a study, solely 33% of individuals consciously use artificial intelligence for a task (PEGA, 2022). This implies that one-third of society has already started to use artificial intelligence applications.

In the accumulated literature, it is clear that artificial intelligence applications are used at a limited level in higher education though (Chen et al., 2020). These applications are frequently used in data search, data analysis, data classification, industrial applications, and engineering. Howbeit, using artificial intelligence applications as an alternative development tool is not recommended much. Instead, it is emphasized that it would be more effective to integrate artificial intelligence applications in the existing curriculum in higher education and make them a part of the education process (Buckingham Shum & Deakin Crick, 2016; Markauskaite et al., 2022; St Louis et al., 2021).

The above feedback has been acted on and some applications have been made to include artificial intelligence applications in existing curricula and to make sure interdisciplinary development (Larson & Miller, 2011). In this frame of reference, Southworth et al. (2023) conducted a curriculum development study on the transformation of higher education. Accordingly, artificial intelligence applications are handled in five different categories. These are classified as access to artificial intelligence applications, ethical use, measurement-evaluation and creativity, application/use, and knowing/understanding. The practicum encompasses artificial intelligence courses, literacy, and competencies. Figure 3 portrays the curriculum arrangements for artificial intelligence applications (Southworth et al., 2023, p.6).

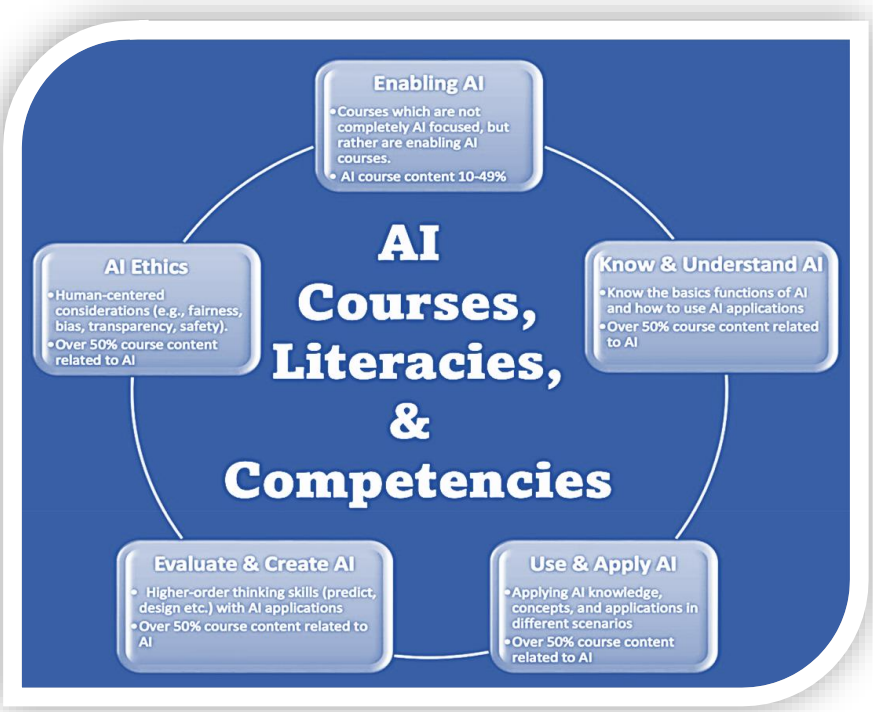

Figure 3. Curriculum arrangements for artificial intelligence applications

It is worth noting herein that a novel concept has emerged in the process of including artificial intelligence applications in curricula at the higher education level. This is entitled *"readiness to use artificial intelligence"* (Jöhnk et al., 2021). That being said, the readiness components for artificial intelligence applications have not yet been completed, they continue to be developed. Alongside this, artificial intelligence readiness studies have begun in the field of educational sciences and in the business sector (Luckin et al., 2022). This depicts that artificial intelligence applications gain more importance professionally.

Another area that should be given importance with regard to the notion of readiness for the use of artificial intelligence in higher education is without doubt teacher training as teachers are the individuals who influence the development of their students to a great extent. On this basis, they should receive a good artificial intelligence education during their higher education studies and have a certain degree of competence.

Several artificial intelligence applications used in the field of education can make judgement like humans to a certain extent. More precisely speaking, these perform a kind of simulation of human behavior via copying it. Albeit it should not be forgotten that artificial intelligence applications have some features that differ from traditional technologies. Traditional technologies give full control to humans, but artificial intelligence applications perform some of the control autonomously by distributing tasks (Damerji & Salimi, 2021). At this juncture, the term "readiness" needs to be revisited and interpreted from a different perspective for educators. It is observed that there exists a bulk of studies on artificial intelligence readiness for educators in higher education. Jöhnk et al. (2021), for instance, interviewed 25 artificial intelligence experts in their study.

Within the scope of the research, an artificial intelligence readiness framework was created. This designated framework has strategic alignment, use of resources, adequacy of knowledge levels (artificial intelligence awareness, skills, ethics), culture formation and use of digital data. In another study, Luckin et al. (2022) conducted a more comprehensive study and adapted artificial intelligence preparedness to education. In this study, which consists of seven different steps, there are the stages of dealing with the idea of artificial intelligence, identifying the challenges that need to be solved in education, identifying, and collecting data to address the challenges, applying artificial intelligence techniques for data analysis, and using the results of artificial intelligence. In another study conducted by Karaca et al. (2021), a scale was developed and students' readiness for artificial intelligence applications in higher education was explored.

When the sub-dimensions of the developed scale are examined, it is obvious that there are cognitive preparation, competence to use artificial intelligence, having a vision of artificial intelligence and ethical use skills. When the studies on artificial intelligence applications are further investigated, readiness materializes as an eminent factor. With this being said, most of the existing studies are at the theoretical and conceptual level. This is an indicator that artificial intelligence applications in higher education need to take place in the education process (Brouillette, 2019; Felix, 2020). Considering the studies in the theoretical pathways, it can be put forward that there are few studies that inspect the effects of artificial intelligence applications in the field of teacher training in higher education to speculate about their effects on the development of prospective teachers (Bhargava et al., 2021; Chounta et al., 2022).

In the 21st century, innovations in science and technology have affected the types of competences and skills that teachers should possess as they graduate. This has led to the formation of new areas of expertise and the adoption of distinct approaches in the formation of the workforce (Buckingham Shum & Deakin Crick, 2016; Kandlhofer et al., 2016). The World Economic Forum (2022) defined the Fourth Industrial Revolution as "the unification of the physical, digital and biological worlds and the renewal of technologies". It should be noted that this does not underline an utterly positive idea. It has also been stressed that this development may have negative aspects and dangerous problems may occur. Thence, necessary preparations should be made to prevent the negative consequences of artificial intelligence applications.

Following this, the United States has taken precautions against the national security sector to create a workforce ready for artificial intelligence and with the aimed advanced digital literacy by the year 2025 (NSCAI, 2021). Aside from this, the ultimate goal of higher education institutions in the United States has become addressing students in the qualified workforce and making them ready for this. For this purpose, colleges and universities are constantly being reviewed and their curricula are being renewed in line with the needs and expectations of the professions (Ahmad, 2019; St Louis et al., 2021). This is valid for teacher training as well. In order to be able to overcome the challenges of the 21st century and to create a qualified workforce, it is deemed vital to educate individuals who have a good command of artificial intelligence applications (NSCAI, 2021).

STRENGTHS and WEAKNESSES of ARTIFICIAL INTELLIGENCE USE in HIGHER EDUCATION

Artificial intelligence applications have been used more extensively in higher education in recent years. These applications are produced by a variety of companies and work independently of each other (Lim et al., 2023); however, it is known that they own a set of similar technical infrastructures. The most popular amongst these is the ChatGPT application produced by OpenAI and released in November 2022. This application reached one million users in five days. Apart from this, it broke the consumer application record by reaching 100 million users within two months (Hu, 2023). The most powerful aspect of the ChatGPT application is that it supports multiple languages and can yield tremendous results in providing structured human-like responses. This feature was highly appreciated by the users and made it attractive to be used for dissimilar purposes, especially at higher education level. As has been mentioned earlier on, while artificial intelligence applications make many positive contributions to higher education, they can also cause many negative consequences. It is frequently criticized against issues like evaluation, authenticity, and ethical violations (Chatterjee & Dethlefs, 2023; Stokel-Walker, 2022). Some countries are not only concerned about this issue, but also prohibit the use of artificial intelligence-supported applications (Lukpat, 2023; Nature, 2023).

Another catalyzing effect of the use of artificial intelligence applications in higher education is for sure the Covid-19 pandemic. With the Covid-19 pandemic, long-term lockdowns were carried out worldwide and many educational activities were transferred to digital environments. This has caused the shareholders to develop digital literacy and interact with technologies more often. Especially at the higher education level, the usages of online tools and the realization of interactive applications have led to the development of this situation. All in all, these have shortened the adaptation and preparation process of people to artificial intelligence applications (Lim et al., 2022).

Considering the tension situation that came up with artificial intelligence applications in the field of higher education, it is seen that anxiety and excitement should be handled in a balanced manner. When approached with a critical discourse, the questions of "is there a need" or "at what level is needed" for artificial intelligence applications may come to mind. There are varying schools of thought as to the advantages and disadvantages of artificial intelligence applications in higher education. In fact, four different paradoxes are explained in the literature. These paradoxes are expressed by Lim et al. (2023) as follows:

1. Are artificial intelligence applications friend or foe?
2. Are AI applications capable/productive or dependent/limited?
3. Do AI applications increase or restrict accessibility?
4. Should AI applications be banned or popularly used?

When the first paradox case is analyzed, it is understood that artificial intelligence applications facilitate users to obtain information in higher education. Features such as writing codes, developing creative ideas, facilitating the writing of articles and theses attracted attention in a short time and were used extensively (Chatterjee & Dethlefs, 2023). On the other hand, this has led to the preparation of assignments of unknown origin in a short period of time and the production of papers and dissertations/theses that are highly similar to one another (Terwiesch, 2023). The applications allow for the writing of a book chapter within minutes. This has created uneasiness about justice, plagiarism, accountability and equality in higher education, and at present, artificial intelligence detectors have started to be placed in many plagiarism control applications resulting in a rather ironic case because these control mechanisms themselves operate as part of AI platforms.

Considering the second paradox, it is argued that artificial intelligence applications such as ChatGPT are quite capable in many fields and produce successful results. It is worthwhile to articulate that this efficiency is linked to the ratio of the information pool and data size. In other words, artificial intelligence applications are far from being independent- at least for now. They only produce human-like responses using an advanced algorithm (Rychen & Salganik, 2003).

The third paradox is among the most frequently questioned situations. The leading companies in the artificial intelligence sector (OpenAI) pronounce that these programs are prepared for the benefit of humanity (OpenAI, 2023). As a matter of fact, this has been made freely accessible in order to universalize knowledge and to be used by all people (Pavlik, 2023). With this initiative, equality in education has been targeted and innovative studies have been designed to enhance accessibility. Especially international students need to eliminate the language barrier so as to easily adapt to higher education (Cheddadi & Bouache, 2021). Artificial intelligence applications offer positive opportunities such as language editing and translation, producing creative content, and eliminating unintentional plagiarism. However, in addition to these positive contributions, applications such as ChatGPT can be kept open for free and at full capacity for a certain period of time. After some time, it restricts accessibility by switching to a paid subscription system. Some services that are accessed free of charge have begun to be offered with slower and more restrictive information over time.

The last paradox is about the prohibition of artificial intelligence applications or the continuation of their popular use. There are many different practices in this sense. To illustrate, the Australian states of New South Wales, Queensland and Victoria have announced that access to ChatGPT will be banned for security reasons (ABC News, 2023; Jaeger, 2023). A similar situation took place in public schools in New York City (Lukpat, 2023). Although these bans include a certain period of time, they may have a great(er) impact on the shaping of the laws that countries will prepare in the long term. The prohibition of artificial intelligence, especially at the higher education level, may in turn lead to counter-formations. For example, the attempt to censor, hide or remove it may cause the society to show more tendency and increase interest in it (Jansen & Martin, 2015). Namely, by creating reverse psychology, individuals may wish to illegally access these applications.

Although there are paradoxes in connection with the use of artificial intelligence in higher education, it is also referred to in many other fields. Especially the preparation of personalized learning environments provides a great advantage (Kong et al., 2021). In the education of disadvantaged groups, these learning environments can create positive results thanks to accessibility (Pechenkina, 2023). At the same time, innovative applications are implemented with smart teaching systems (O'Connor & ChatGPT, 2023). This provides continuous and instant feedback for students. Creating alternatives to course materials from time to time, providing material richness and personalized performance applications can be shown among the positive developments (Holden et al., 2021). Moreover, chatbots and virtual assistants can be used for students who want to receive psychological and social support. These applications, which respond to students without judgement, can actually provide support in many ways. Another positive feature of artificial intelligence applications is that they perform measurement and evaluation procedures and support researchers in the data analysis process (Dibble, 2023). The use of artificial intelligence and chatbots in higher education alters the role of teachers and students in the classroom from time to time. In traditional education, teachers are more active, yet artificial intelligence applications begin to individualize the learning process over time and reduce the dominance of teachers in the classroom (University, 2023). In parallel with this, students tend to learn individually and become more active (Hammer, 2023). However, this progresses positively up to a certain point. Because the ability of artificial intelligence applications to produce content is (currently) limited. Therefore, it is not possible to fully replace instructors for now and whether doing so would be ethical or feasible is yet another question. However, supporting teachers and students in the education process can be seen as a positive development. There is not yet an international law or frame on the use of artificial intelligence applications in higher education and on the legal limits. It is known that preparations are being made by some countries though. This also brings up the ethical use of artificial intelligence applications (Becker et al., 2018). Artificial intelligence applications can make positive contributions to the performance of students and academics, back up their gaining experience, and most importantly, help develop creative thinking skills, with the negative effects they might bring about (Jalal et al., 2021). The fact that there is no law, law or regulation for artificial intelligence applications paves the way for the use of these applications at times in unlimited and illegal ways (Holmes et al., 2021). Even though artificial intelligence applications attempt to help people improve their mental skills it is declared that they cause behavioral changes in students after a certain period of time and make them more impatient and less thinking individuals (Borenstein & Howard, 2021). Artificial intelligence and chatbots can also affect international students' learning experiences and their ability to access education. In this context, especially students with language deficiencies and communication problems can be easily included in the process. At the same time, learners with special needs can overcome their disabilities with interactive applications offered by artificial intelligence applications and receive education in universities. This creates positive results for equality in higher education (Zhai, 2022).

An INVESTIGATION of ARTIFICIAL INTELLIGENCE in HIGHER EDUCATION towards TEACHER TRAINING

There are many different professional practice areas in higher education. Among these fields, teacher training has its own place. Teacher training programs intend for the training of qualified teachers working at many different levels from pre-school to high school and for the creation of a high-level workforce (Babic, 2017). Teacher training programs constitute an arena that needs to be constantly kept up-to-date and technological competencies should always be on the agenda in their curricula (Buckingham Shum et al., 2019). Bearing in mind this, prospective teachers should be well-trained and graduate with the skills required by the age. It is well known that pre-service teachers take information and technology courses in university environments globally (Chi et al., 2011). However, the majority of these courses lead to the acquisition of rather basic literacy skills. What is more, existing programs may be insufficient in view of the ethical uses of technology and on the subject of ethical practices (Duffy & Azevedo, 2015). On top of everything, there is no legal regulation or restriction on the uses of artificial intelligence. This may cause pre-

service teachers to use artificial intelligence applications unethically. With a view to preventing these situations, it is essential to prepare laws and regulations for higher education and to plan awareness trainings for prospective teachers. At the same time, the inclusion of elective and compulsory courses within the scope of these regulations may also appear as alternative practices (Nazaretsky et al., 2021) so when they teachers begin their professional lives these help them to be more successful (Weston-Sementelli et al., 2018). In addition to the existing curriculum in higher education, professional development areas should also be supported e.g., technology and computer literacy, coding, software, and big data analysis can be prepared as additional applications where artificial intelligence applications are active.

In higher education programs, teacher candidates are aimed to be equipped with many different skills. These skills include critical, creative (Ayyıldız & Yılmaz, 2021) and inquisitive thinking, problem solving, leadership (Ayyıldız & Yılmaz, 2023), decision making and reasoning (Yang et al., (2018). However, in the WEF (2022) meeting, it was announced that new and different skills may be required by the years 2025 and 2030. These skills cover software and coding, artificial intelligence literacy, algorithm generation, multi-criteria decision making and stress management. Thus, teacher training programs need to be renewed according to the needs of the age and transformed to adapt to the popular areas of the future, especially artificial intelligence applications.

Highlighted Results and Suggestions for the Future

The present study can be interpreted in two main tracks so that it can shed light to the future. The first track points out to the studies that will concentrate on AI in and for higher education. In the matter of research on AI, it would be both meaningful and purposeful for scholars from distinct disciplines to cooperate and collaborate to open the way for multidisciplinary, interdisciplinary, and transdisciplinary research, which is extremely important to focus on the divergent angles i.e., societal, andragogical, psychological and political angles of this inherently complex issue. As for the aforementioned second track we would like to accentuate that decision making bodies, policy makers and authorities need to work together to establish the required infrastructure, intellectual capital and ethical schemes for AI to be best integrated into the idiosyncratic world of higher education.

Declaration of Conflicting Interests

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author received no financial support for the research, author-ship, and/or publication of this article.

Statements of publication ethics

I hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

Since This research is a literature review study, ethics committee permission is not required.

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 411-418
doi: 10.24106/kefdergi.1683550

| Research Article / Araştırma Makalesi |

A Process-Oriented Approach to English Curriculum Design: A Case Study

İngilizce Öğretim Müfredatının Kolektif Bir Öğrenme Süreci Haline Getirilmesi: Bir Vaka Çalışması

Güzide Çalışkan[1],**Fulda Karaazmak**[2]

Keywords

1. Process-oriented curriculum
2Teacher agency
3. Collaborative syllabus design
4. English curriculum unit

Anahtar Kelimeler

1.Süreç Odaklı Müfredat
2.Öğretmen Etkinliği
3.İş birlikli müfredat tasarımı
4. İngilizce müfredat birimi

Received/Başvuru Tarihi
25.09.2024

Accepted / Kabul Tarihi
27.01.2025

Abstract

Purpose: The purpose of this study is to explore the role of instructors in English curriculum design and to further investigate whether a top-down curriculum assigned by the curriculum unit or one developed collaboratively with instructors would yield better results.

Design/Methodology/Approach: In this case study, a qualitative research design was conducted to determine instructors' attitudes toward a process-oriented curriculum during the spring semester of 2023-2024. Data was gathered through semi-structured interviews and focus group discussions and analyzed using thematic analysis procedures. The research was carried out in one of the private universities in Türkiye and included eight instructors (two male and six female) with more than ten years of experience in English language teaching at different levels.

Findings: The study revealed that both a curriculum prepared by a unit with trained staff and a curriculum including all the teaching staff have ups and downs. In addition, participants reported increased process awareness when included in curriculum design yet highlighted organizational challenges. if carefully organized and scaffolded, a process-oriented curriculum with the collaboration of both instructors and curriculum unit would generate better outcomes.

Highlights: Curriculum, content, and instructional planning are among the most influential predictors of success in language classes. The individuals involved—whether classroom instructors or curriculum designers—play a critical role in determining that success. When instructors have a voice in curriculum development, they gain a deeper understanding of its content and the rationale behind each step. Conversely, a strictly top-down approach, where each step is prescribed by the curriculum unit, may compromise quality and limit flexibility. Therefore, exploring the most effective practices is necessary and valuable.

Öz

Çalışmanın amacı: Bu çalışmanın amacı, İngilizce müfredat tasarımında öğretim elemanlarının rolünü incelemek ve müfredat birimi tarafından yukarıdan aşağıya atanan bir müfredat ile öğretim elemanlarıyla iş birliği içinde geliştirilen bir müfredatın hangisinin daha iyi sonuçlar vereceğini araştırmaktır. Müfredat, içerik ve öğretim planı, dil sınıflarındaki başarının en etkili belirleyicileri arasındadır. İster sınıfta görev yapan öğretim elemanları ister müfredatı hazırlayan kişiler olsun, bu sürecin aktörleri, başarının belirlenmesinde önemli bir rol oynar. Müfredat hakkında söz sahibi olan öğretim elemanları, içeriğe dair daha derin bir anlayış kazanır ve her adımın arkasındaki gerekçelerin farkına varırlar. Ancak müfredat birimi tarafından yukarıdan aşağıya bir süreçle her adımın önceden belirlenmesi, kaliteyi tehlikeye atabilir ve esnekliği engelleyebilir. Bu nedenle en verimli uygulamaları araştırmak oldukça değerlidir.

Materyal ve Yöntem: Bu vaka çalışmasında, nitel bir araştırma deseni benimsenmiş ve 2023-2024 bahar döneminde süreç odaklı müfredata yönelik öğretim elemanlarının tutumlarını belirlemek amaçlanmıştır. Veriler yarı yapılandırılmış mülakatlar ve odak grup görüşmeleri yoluyla toplanmış, tematik içerik analizi yöntemleriyle analiz edilmiştir. Araştırma, Türkiye'deki bir vakıf üniversitesinde gerçekleştirilmiş ve farklı düzeylerde on yılı aşkın İngilizce öğretim deneyimine sahip sekiz öğretim elemanı (iki erkek, altı kadın) ile yürütülmüştür.

Bulgular: Bu çalışma, hem eğitimli personelden oluşan bir birim tarafından hazırlanan bir müfredatın hem de tüm öğretim kadrosunun dahil olduğu bir müfredatın artı ve eksilerinin olduğunu ortaya koymuştur. Ayrıca katılımcılar, müfredat hazırlama sürecine dahil olduklarında, sürece dair farkındalıklarının arttığını ancak örgütsel zorlukların da bulunduğunu belirtmişlerdir. Yine de süreç odaklı bir müfredat, her iki tarafın iş birliğiyle dikkatli bir şekilde organize edilir ve gerekli destekleme sağlanırsa, daha iyi sonuçların doğurabileceği sonucuna varılmıştır.

Önemli vurgular: Müfredat, içerik ve öğretim planlaması, dil sınıflarındaki başarının en güçlü belirleyicileri arasındadır. Bu sürece dahil olan kişiler —ister sınıf içindeki öğretim elemanları ister müfredat tasarımcıları olsun— başarının şekillenmesinde kritik bir rol oynar. Öğretim elemanları müfredat geliştirme sürecinde söz sahibi olduklarında, içeriği daha iyi kavrarlar ve her adımın arkasındaki gerekçeleri anlayabilirler. Öte yandan, müfredat birimi tarafından adım adım yukarıdan aşağıya belirlenen bir yaklaşım, kaliteyi tehlikeye atabilir ve esnekliği sınırlandırabilir. Bu nedenle en etkili ve verimli uygulamaları araştırmak hem gerekli hem de değerlidir.

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Citation/Alıntı: Çalışkan, G., & Karaazmak, F. (2025). A process-oriented approach to English curriculum design: A case study. *Kastamonu Education Journal*, 33(2), 411-418. doi: 10.24106/kefdergi.1683550

INTRODUCTION

Being the language of science, business, and technology, teaching and learning English have gained more importance and, as a result, have gone through abundant adjustments for the last decades. Because of its significance, there has been immense research on delivering English content best so that learners get the most out of it. One of the most important determiners of success in teaching English is executing the curriculum and the syllabus. Even though most scholars use curriculum and syllabus interchangeably, some distinguish between the two concepts.

To start with, Krahnke (1987) termed curriculum as a general map containing more than one syllabus, which is more specific and concrete than the curriculum. In his view, the curriculum defines the goals that the learners achieve at the end of the instruction, while the syllabus establishes the lesson's content. Graves (2016) further expresses the curriculum as the course plan that describes how the content is turned into outlines for teaching and learning to reach the target goals and objectives. According to Richards (2013), a curriculum is a proposal for acquiring information. He classified the curriculum as backward, forward, and central. In the backward design, the specifications are decided at the beginning, and instructional processes are developed accordingly. In other words, goals and standards are predetermined, and content is arranged to realize them. Tyler (1949) and Taba (1962), two influential scholars in curriculum and instruction, put forward a different approach to curriculum. This approach, which is regarded as a product approach, lost popularity as the process approach became popular, yet its influence is still evident in most curriculum and syllabus designs conducted today. That said, the purpose of the curriculum is to clarify what and how students will learn while the syllabus, dependent on the curriculum, is how the contents are designed into docile and learnable units with the arrangement of the sequences.

Ylimaki (2013) brought a different perspective by categorizing the curriculum as the intended, the enacted, the assessed, the learned, and the hidden curriculum. As this section cannot explain all these types in detail, it will be good to briefly state that most educators today agree on the dynamic interplay between curriculum and its phases, which inevitably impacts the syllabus. In other words, "the processes of planning, enacting, and evaluating are interrelated and dynamic, and should not be linear. They move back and forth to inform and influence each other" (Graves, 2008, p. 152).

Though the name attributed to the curriculum changed by overemphasizing one phase over another or by changing the sequences of the phases and adding another phase according to the time needed, the overall goal to deliver the content to serve a particular purpose remained the same. Whereas the language stands as a means of conducting that purpose, the discussion of who should decide on the curriculum content and the syllabus has still been an argumentation issue.

Until recently, stakeholders such as publishers, school administrations, or curriculum units prescribed the language curriculum and syllabus, hence, the role of teachers in decision-making was restricted. Therefore, to the best of our knowledge, the literature on teachers as curriculum and syllabus design agents has been limited. This case study is conducted to add literature by closing this gap and to illuminate the readers curious about curriculum design practices by unfolding the changes that came up throughout a process where teachers planned the English curriculum at different levels in teams, stated their concerns, and suggestion. Finally, implications for prospective researchers are provided.

Literature review

This section clarifies the readers by explaining significant factors affecting curriculum design in English language teaching and exhibits studies done in this respect. In the study, the English syllabus was treated as a component of the curriculum preparation phase and thus is not separated from the curriculum as a distinctive entity.

The English language teaching curriculum content has gone through several changes as the research expanded in this field. The number of people willing to learn English increased, as did the concerns and the needs related to teaching it. Consequently, people wanted to learn English for different purposes, which imposed different curricula and syllabuses. It would not be sensible to apply the same curriculum to other cohorts of students with different purposes for learning English. Similarly, it is not logical to leave the preparation of the curriculum and syllabus to solely one unit of the same people, excluding teachers since teachers are the ones who are more knowledgeable on classroom practices, and hence should be involved at all stages of curriculum development (Mwanza & Chishimba, 2023).

Though the necessities changed, the curriculum content and application still carried the traits of previous applications. In other words, they shared many similarities in functions. Graves (2017) supports this by saying that although the approaches to language teaching have changed throughout the years, there are many overlaps and similarities in theory and implementation.

Graves (2016) divided the curriculum related practices into three groups: the linguistic wave, the communicative way, and the third wave. According to him, language, though commonly regarded as a subject, is not a school subject. It is a source to make meaning. Hence, its content needs to be merged into a curriculum. In his description, the linguistic wave is highly dependent on

the forms of language, and the communicative wave highlights the function of language in developing the four macro skills: reading, writing, listening, and speaking. The second wave, popularized as the linguistic wave did not help the learners perform the language in different social settings and did not consider individual needs. Unlike the ones mentioned, the third-wave curriculum considers the learners and the teachers as significant shareholders and their roles in the syllabus-making process are stressed.

In most institutions, teachers are regarded as the means of carrying out the curriculum planned by others. Teachers' role in such situations is like a musician playing a piece of music composed by a different writer. However, teachers' proficiency in the classroom reality is crucial for discerning the problems that call for curriculum remedies (Peretz, 1980). Though Schwab (1973) emphasized the significance of the anticipated learner and the subject matter as the most critical parameters of the syllabus-development process, Elliot and Macdonald (1975) pointed out that a curriculum that considers only learners but not the teachers is never complete, calling for an active participation of teachers in curriculum design.

Teachers' dynamic role in curriculum development enhances their skills and proactive behaviors. The stakeholders, such as teachers, managers, learners, test developers, and curriculum managers, add to the curriculum development with their diverse experiences and opinions. Primarily, teachers as planners and practitioners of the syllabus play a substantial position in developing the curriculum (Cincioğlu, 2014). Put simply, teachers are indispensable in creating and adapting the curriculum and, inevitably, the syllabus. As Sahlberg (2015) claims, "Teachers improve by learning from each other. Isolation is the enemy of all improvement" (p.18). Hence, creating a cycle among teachers to work on curriculum guarantees positive outcomes for the learners and teachers.

In his case study, Hadley (1999) concludes that to adopt the innovations in the curriculum, teachers, being "valuable team members, should be allowed to play a greater part in decisions regarding curriculum, which inevitably affects their classes" (p. 98). In addition, including teachers in the curriculum development and allowing them to participate in its creation is noteworthy as teachers are the ones who practice it in authentic classroom contexts (Dündar & Merç, 2017). If somebody else prepares the curriculum, teachers must spend extra effort to comprehend it as they can better prepare activities for their "students if they are the ones designing those experiences with their particular students in mind" (Bishop & Harrison, 2021, p. 3).Therefore, if they become a part of the process, they will influence the success with their experiences and opinions (Alsubaie, 2016). In his study, Fullan (1991) found that including teachers in the curriculum preparation process led to effective and positive educational changes. Another scholar, Handler (2010), concluded that it is necessary to make teachers a part of the curriculum as they complement it by working collaboratively with curriculum development teams and ensuring the alignment of the content with the learners' needs.

Young et al. (2018) claim that teachers feel a sense of fitting and improve their dialogue with staff when they participate in curriculum preparation. He further asserts that teachers also feel optimistic about improving teaching quality. Teachers who consistently participate in curriculum development advance their skills of professionalization as it mostly depends on the extent of their involvement in such events (Nixon et al., 1997). Additionally, they feel more competent in the teaching and the content when they are not considered as only the receiver of the curriculum (Bennet et al., 1992). In other words, when teachers participate in curriculum activities, whether preparation or adaptation, they develop their skills and feel capable of performing them.

To wrap up, teachers who experience curriculum or syllabus preparation and development feel more competent and enhance their teaching skills, work collaboratively with their colleagues, and improve their dialogue with them. Their acceptance of the curriculum becomes straightforward. After all, it is much more satisfying to play your melody than someone else's after all.

Research questions

Considering the aims, this study deploys a qualitative approach to respond to each research question stated below:

1. Which of the following do English instructors prefer concerning time effectiveness and academic quality of the syllabi, and why?
   a) A ready-made curriculum prepared by a curriculum unit
   b) Being part of a collaborative curriculum preparation process
2. How does being part of a collaborative curriculum preparation process affect instructors' instructional practices?
3. What are instructors' suggestions regarding the collaborative curriculum preparation process?

METHOD/MATERIALS

This section clarifies the reader by explaining the participants, the instruments, data collection process and data analysis procedures.

Sample / Participants

Eight English instructors, comprising two men and six women currently working in an English preparatory school of a university in Türkiye, contributed to this study during the academic year of 2023-2024. Purposive sampling was implemented. The sampling method was considered to limit sampling to actively working English preparatory school instructors. All participants had more than ten years of English teaching experience at different universities. They all graduated from one of the universities' foreign language teaching programs like English literature, or English linguistics departments. They all participated in curriculum and syllabus design many times, thus exhibiting a suitable profile to gather data.

Instrument(s)

Deploying a qualitative approach, the data for this study were collected through semi-structured and focus group interviews. The researchers prepared and validated the interview questions on data triangulation, taking the opinions of three field experts and a native English speaker. The interview questions included two parts: The first was designed to collect sociodemographic data (experience, academic degree), and the second consisted of open-ended questions designed to answer the research questions.

Data collection procedures

The context of this study is an English preparatory school of a foundational university in Türkiye. The qualitative research data were collected in two phases after getting the consent forms signed by the interviewees. In the first phase, interviews were conducted face-to-face with purposively selected English instructors working in this preparatory school based on the years of experience, and the departments graduated. Instructors were interviewed separately, and each interview lasted approximately 15 minutes. In the second data collection phase, the interview was designed as a focus group interview where the instructors discussed the interview questions all together at one shot. This phase lasted approximately half an hour. All interviews were recorded with the interviewees' consent and secured on the researchers' computers. The data collection procedure took approximately two weeks.

Data analysis

Thematic content analysis was conducted to find common themes in the data. Following the data collection, the researchers transcribed all the voice-recorded interviews into written form and performed the analyses separately to increase the reliability. A comparative method (Glaser & Strauss, 1967) was used to analyse the qualitative data from different perspectives. That is, the researchers compared their interpretations of the data to increase the interrater reliability, which could also be considered a manner of triangulation to validate research results more accurately.

To go into more depth in analysis steps, the interviews were recorded first and then transcribed verbatim. Related words and phrases in the responses were then collated and labelled under the relevant codes by the two researchers separately after iterative readings of the data. To ensure further reliability, both researchers, then separately repeated extensive coding of the interviews. After reaching the most repeated codes, they then grouped the codes under discrete categories. The results were compared later to compromise on common themes. After that, each theme went through in-depth analysis to see the connections and make sound conclusions.

Results

Below is a matrix showing the initial codes, categories, and themes driven by the transcribed data. Later, each theme was analyzed separately by providing examples from the transcriptions.

Table 1

Perspectives on the syllabus unit vs. collaborative curriculum preparation

	Codes	
	Curriculum Unit	Collaborative Curriculum Preparation
Pros	➢ More time-efficient and organized ➢ Being able to see the whole picture	➢ Feeling more responsible in decision-making

	Codes	
	➢ Foreseeing possible problems before they occur ➢ Providing a linear connection among all proficiency levels ➢ Combining feedback gathered over the year and applying it to the prospective curriculum	➢ Adapting to the process more efficiently ➢ Fewer criticisms/ no offensive criticisms ➢ More critical evaluation of the process ➢ Increased process awareness ➢ A sense of belonging within the institution ➢ The bottom-up process leads to hearing more voices.
Cons	➢ Top-down process: Being ordered what to do ➢ No different perspectives	➢ Not being able to see the whole picture ➢ Discrepancies among level syllabi ➢ More hectic and time-consuming ➢ Requiring more organization ➢ Work ethics and allocating equal workload among instructors ➢ Better group dynamics are needed ➢ Problems solved after they occur
Categories		
	Curriculum Unit	Collaborative curriculum preparation
	➢ Organization ➢ Time efficiency ➢ Whole-picture awareness ➢ Connected syllabi ➢ Top-down process	➢ Increased process awareness ➢ Critical process evaluation ➢ Bottom-up process ➢ Time-consuming ➢ Group dynamics and workload issues in groups ➢ No whole-picture awareness
	Themes	
➢ Organizational issues ➢ Pedagogical issues o Bottom-up vs. top-down processes o Syllabus quality and time effectiveness o The whole picture and interconnection		

Theme 1: Organizational issues

There were some differences in the interviewees' ideas regarding the organizational aspects of the two different curriculum preparation processes, as a curriculum unit and as a collaborative curriculum preparation. Participants put forward that the collaborative curriculum preparation process required more organizational preparedness. They noted the problems they experienced during the collaborative curriculum preparation emerging from the lack of careful organization, which is evident in a comment from an interviewee below:

> "I saw that curriculum preparation could become more hectic without careful organization. Everybody should know what they are supposed to do, and the workload should be distributed as equally as possible."

In turn, concerning having a curriculum unit, all the participants stated that it was more organized because unit members would know what they were supposed to do, unlike the reported hectic nature of the collaborative curriculum preparation process, as can be seen in the excerpt below:

> "I prefer having a curriculum unit in the school. This experience of preparing the curriculum together was a lot more hectic for me because of the lack of necessary arrangements, time, and guidance during the process."

Another concern arose about the organizational difficulties experienced during the collaborative curriculum preparation related to group dynamics and work ethics. The research results highlighted the importance of careful planning and distributing the workload among group members for this collaborative curriculum preparation procedure to work smoothly, as explained by one of the interviewees:

> "I think the real problem I experienced during this process was the inequality in the group workload. To clarify, one of my group members and I did all the work normally all the group members should have completed; one member did not actively participate in group task."

Theme 2: Pedagogical issues

Bottom-up vs. top-down curriculum preparation processes

Participants described two approaches to curriculum preparation processes investigated in this study differently regarding their structural nature. They defined these preparation processes as 'bottom-up' and 'top-down.' For this article, the terms 'bottom-up' and 'top-down' refer to workload delegation within a hierarchical organization. 'Bottom-up' describes the creation of structural work processes being created and developed by the workforce body that is at once the lowest rank of the management hierarchy and who is to administer said processes. Conversely, 'top-down' describes said work processes as being created and developed by a workforce body at any level higher on the management hierarchy. The collaborative curriculum preparation experience was described as a bottom-up process, meaning that all the instructors were involved in the preparation phase, taking more responsibilities, which resulted in increasing their process awareness, as explained in the excerpt below:

> "During this new experience, I have felt more responsible for all the decisions made regarding the curriculum. I have also observed the curriculum preparation process closely with all its pros and cons."

The traditional way of curriculum preparation, which is having a curriculum unit, was described as a top-down process. One interviewee explained that issue as follows:

> "When we have a curriculum unit, I feel like I am ordered to do whatever is written in the curriculum without questioning anything. The curriculum becomes a rule to obey because I feel I have no right to change anything in it."

Curriculum quality and time effectiveness

Some different viewpoints were expressed regarding the quality of the curriculum prepared by a curriculum unit and as a result of the collaborative curriculum preparation process. Results showed that most participants stated the high quality and time effectiveness of the curriculum prepared by a curriculum unit. Correspondingly, the collaborative curriculum preparation process was viewed as time-consuming because of the lack of careful planning, and the curriculum quality was viewed as lower, as stated in an excerpt below:

> "The collaborative curriculum preparation process I attended was time-consuming, and the result was not very good. During the semester, we needed to change the syllabi a few times, excluding some units in the books, etc., which shows the low quality of the curriculum prepared."

Another interviewee stated the following:

> "For this collaborative curriculum preparation process to work efficiently, we should have more time, and the group roles should be assigned to each member beforehand. How we did it was not time effective; group members did not do their parts as effectively as we had hoped.

The whole picture and interconnection

The whole picture awareness, meaning the relation among the different syllabi for each language proficiency level and their interconnection, was another critical concern, according to the study results. Regarding the collaborative curriculum preparation, it was stated that the in-depth analysis and awareness of a single-level syllabus was higher for each group preparing the corresponding one. However, the linear connection among the syllabi was missing because of the inability to see the whole picture. That was not the case in the syllabi prepared by a unit. This issue was noted by one of the interviewees as follows:

> "I was responsible for A1 and A2 syllabi; I know them because my colleagues and I prepared them. However, my colleagues told me there were some problems reaching the level objectives in the other syllabi. What I mean is that I think the linearity from the A1 level to the B2 level was not achieved successfully since different groups of instructors were responsible for different syllabi, which led to losing the interconnection among them."

Discussion

Regarding RQ1, one result reached was that collaborative curriculum preparation was regarded as a more inclusive procedure, leading to all the instructors taking responsibility instead of being provided with one in which instructors did not have a say, and hence instructors would prefer to be included in the process instead of being only the receiver of the curriculum. Yet, the study results illustrated that having a curriculum unit without the inclusion of instructors and collaborative curriculum preparation with the inclusion of instructors had both upsides and downsides. As a novice and inclusive process, collaborative curriculum preparation has some beneficial qualities but requires more careful planning to be used effectively, as mentioned by Fullan (1991) too.

Regarding RQ2, as shown in the study results, the quality of the curriculum and time concerns were related to the organizational and structural issues. They seem to be interrelated, influencing each other and the effectiveness of the whole process. A similar result was reached by Bennet et al. (1992). In terms of in-depth process awareness, the collaborative curriculum preparation seemed adequate, but some problems arose regarding the interconnections of each syllabus for different proficiency levels. Consequently, it was found that careful planning and organization were critical concepts in the collaborative curriculum preparation process.

Regarding RQ3, one of the most critical results attained in this study was that instructors' role in the curriculum preparation process assisted them in feeling more responsible and inclusive in the whole process, supported by Cincioğlu (2014). By taking responsibility for the collaborative curriculum preparation process, participants also stated that they learned from each other, having a significant role in professional development, as Nixon et al. (1997) and Sahlberg (2015) also asserted.

To warp up, the results of this study demonstrated that having a curriculum unit was somewhat favoured among the participants, perhaps due to their familiarity with the process. However, some concerns in practice were raised about the traditional way of curriculum preparation, which is one prepared by the curriculum unit. As the last point, it can be affirmed that if used in a well-planned and organized way, collaborative curriculum preparation might be a successful way of including all the stakeholders in the process, as supported by Dündar and Merç (2017) and Handler (2010).

Conclusions

In this section, the researchers' suggestions and the participants' recommendations for an inclusive curriculum preparation process are expressed as institutional practices and recommendations for further research are given.

To conclude, collaborative curriculum unit is recommended to be comprised of experts with efficient knowledge of syllabus preparation and curriculum development. Curriculum unit members should have the expertise to guide/train the instructors. Instructors can be provided with checklists or guided questions to evaluate the syllabi and to provide feedback to the curriculum unit. Taking instructors' feedback and assessing the feedback prompt would be crucial. Different viewpoints should be considered when there is a curriculum unit, so it should not be a prescribed process. Instructors should be included, but mostly in adapting an existing syllabus and providing feedback. The study is not without limitations. As it deployed a small-scale case study research design, the number of participants is small, and the research is context-specific, so the results cannot be generalized. Further studies may apply a mixed-method research design, including a larger population from different institutions to draw sound inferences. Ina addition, current practices in teacher training programs and professional development units in other institutions regarding curriculum preparation might worth searching.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Statements of publication ethics

We hereby declare that the study has no unethical issues, and that research and publication ethics have been observed carefully.

Güzide Çalışkan and Fulda Karaazmak conceived of the presented idea, developed the theory and performed the computations together. They verified the analytical methods and supervised the findings of this work. Both authors discussed the results and contributed to the final manuscript.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

Ethical approval for the current study was taken from the Social Sciences & Humanities Ethics Committee at Çankaya University (22/04/2024).

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Kastamonu Education Journal, 2025, Vol. 33, No:2, 419-434
doi: 10.24106/kefdergi.1683541

| Research Article / Araştırma Makalesi |

The Corrosive Effect of School Administrators as Toxic Leaders on Teacher Accountability

Toksik Lider Olarak Okul Yöneticilerinin Öğretmen Hesap Verebilirliğindeki Yıpratıcı Etkisi[1]

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Keywords

1. Toxic leadership
2. School administrator
3. Teacher accountability

Anahtar Kelimeler

1. Toksik liderlik
2. Okul yöneticisi
3. Öğretmen hesap verebilirliği

Received/Başvuru Tarihi
29.08.2024

Accepted / Kabul Tarihi
26.10.2024

Abstract

Purpose: To examine teachers' views on the corrosive effect of toxic leadership behaviours of school administrators on teacher accountability.

Design/Methodology/Approach: The study group of this research, which uses phenomenology as a qualitative research design, was selected using maximum variation sampling method, which is a type of purposive sampling. This group consists of 20 teachers working in 10 public schools in the central district of Isparta. Data were collected from the teachers through a semi-structured interview form. The collected qualitative data were subjected to contextual analysis through MAXQDA software and visualised. The findings show that the majority of teachers reported that toxic leadership has a detrimental effect on teacher accountability.

Findings: Toxic leaders, characterised by behaviours such as micromanagement, lack of empathy, and aggressive communication, were found to cause teacher demotivation, alienation, and professional burnout. In addition, toxic leaders erode teacher accountability by creating a negative and insecure organisational climate.

Highlights: Toxic leadership behaviours of school administrators are a critical factor that significantly affects teacher accountability. The various dimensions of this impact are as follows: Decreased teacher motivation, psychological safety and job satisfaction, decreased performance and productivity, impeded professional development, stress and burnout. In addition to these, toxic leadership has a negative impact on school climate. A negative school climate leads to a decrease in teachers' willingness to cooperate and be accountable. This can also negatively impact student achievement because lack of co-operation and support among teachers reduces the quality of education. Therefore, it is important for school administrators to exhibit more positive and supportive leadership behaviours to increase teachers' motivation and strengthen their accountability.

Öz

Çalışmanın amacı: Okul yöneticilerinin toksik lider davranışlarının öğretmen Hesap verebilirliğindeki aşındırıcı etkisine ilişkin öğretmen görüşlerini incelemektir.

Materyal ve Yöntem: Nitel araştırma deseni olarak fenomenolojiyi kullanan bu araştırmanın çalışma grubu, amaçlı örneklemenin bir türü olan maksimum çeşitlilik örnekleme yöntemi kullanılarak seçilmiştir. Bu grup Isparta'nın merkez ilçesindeki 10 devlet okulunda görev yapan 20 öğretmenden oluşmaktadır. Öğretmenlerden yarı yapılandırılmış görüşme formu aracılığıyla veriler toplanmıştır. Toplanan nitel veriler, MAXQDA programı aracılığıyla içeriksel analize tabi tutularak görselleştirilmiştir. Bulgular öğretmenlerin çoğunluğunun toksik liderliğin öğretmen hesap verebilirliği üzerinde zararlı bir etkisi olduğunu bildirdiğini göstermektedir.

Bulgular: Mikro yönetim, empati eksikliği ve agresif iletişim gibi davranışlarla karakterize edilen toksik liderlerin öğretmenlerde motivasyon eksikliği, yabancılaşma ve mesleki tükenmişlik gibi olumsuzluklara neden olduğu tespit edilmiştir. Ayrıca toksik liderlerin olumsuz ve güvensiz bir örgüt iklimi oluşturarak öğretmen hesap verebilirliğini aşındırdığı belirtilmiştir.

Önemli Vurgular: Okul yöneticilerinin toksik liderlik davranışları, öğretmenlerin hesap verebilirliğini önemli ölçüde etkileyen kritik bir faktördür. Bu etkinin çeşitli boyutları şu şekildedir: Öğretmen motivasyonunda azalma, psikolojik güvenlik ve iş tatmini, performans ve verimlilikte düşüş, profesyonel gelişimin engellenmesi, stres ve tükenmişlik. Bunlara ek olarak toksik liderlik, okul iklimini olumsuz yönde etkilemektedir. Olumsuz bir okul iklimi, öğretmenlerin iş birliği yapma ve hesap verebilir olma isteklerini azaltmaya sebep olmaktadır. Bu durum öğrenci başarısını da olumsuz etkileyebilmektedir, çünkü öğretmenler arasında iş birliği ve destek eksikliği, eğitim kalitesini düşürmektedir. Bu nedenle, okul yöneticilerinin daha olumlu ve destekleyici liderlik davranışları sergilemeleri, öğretmenlerin motivasyonunu artırmak ve hesap verebilirliklerini güçlendirmek için önem arz etmektedir.

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Citation/Alıntı: Şenol, N., & Taş, S. (2025). The Corrosive Effect of School Administrators as Toxic Leaders on Teacher Accountability. Kastamonu Education Journal, 33(2), 419-434. doi: 10.24106/kefdergi.1683541

INTRODUCTION

Education is one of the most important forces shaping the future of societies and this power is realized through the devoted work of teachers working in schools (Cemaloğlu & Özdemir, 2019). The sustainability of dedication and commitment largely depends on the leadership style of school administrators. Leaders are individuals who directly affect the spirit and culture of the school and the professional lives of teachers (Turan, 2020). However, in addition to leaders who influence and develop positive behaviors, there are also leaders who undermine them. In the literature, such leaders are called toxic (Çelebi et al., 2015). Toxic leaders prevent employees from being creative by exerting strict control over them (Doğan & Aslan, 2024). By controlling communication and information networks, they encourage abstraction, suspicion and an unhealthy organizational environment (Orunbon & Ibikunle, 2023). By preventing the formation of good relationships between people, they reduce productivity and cause employees to disengage both from the organization and from each other (Klahn Acuña & Male, 2024). In other words, toxic leadership can have a corrosive effect on the entire education system (Dahlan et al., 2024). One area where toxic leadership has a particularly corrosive effect is teacher accountability. Teacher accountability is one of the most fundamental building blocks of an educational institution (Baidoo-Anu & Ennu Baidoo, 2024). Teachers' adherence to professional standards and providing students with the highest quality education is a result of their accountability (Jena, 2023). However, toxic leadership behaviors of school administrators can erode teachers' commitment to fulfilling these responsibilities (Rosenblatt & Wubbels, 2021). In such an environment, teachers may show weakness not only in fulfilling their duties but also in their responsibilities towards their students.

Educational administration and leadership studies have generally focused on positive leadership models, effective management strategies and factors that increase teacher motivation, but the effects of destructive leadership behaviors such as toxic leadership on teachers have not been sufficiently examined. By focusing on the dark side of leadership behaviors, this study reveals how toxic leadership undermines teacher accountability in educational institutions and its negative effects on the quality of education. By raising awareness of how negative behaviors exhibited by leaders, especially in the field of education, can erode teachers' professional accountability, this study shows that leadership behaviors have long-term effects not only on teachers but also on school climate and student achievement in general. At this point, the study not only makes a theoretical contribution to the educational administration literature, but also raises awareness of the need to reassess leadership behaviors in practice.

Toxic Leadership

Today, the concept of leadership is predominantly portrayed with a positive connotation (Gündüz & Dedekorkut, 2014). However, it is important to understand that leaders are not infallible heroes who positively guide their stakeholders without making any mistakes. This is because leaders may at times exhibit negative behaviors or make critical mistakes that jeopardize the interests of the majority. Recognizing this reality, some scholars have moved away from idealized portrayals of heroic leaders and have begun to view leadership from a more comprehensive perspective, including the negative aspects of leadership (Eliveren et al., 2023). Various studies examining manipulative, destructive and toxic leadership behaviors that lead to negative outcomes shed light on the darker sides of leadership, especially as it concerns individuals and groups (İlhan & Çelebi, 2021).

The beginnings of the toxic leader concept are attributed to Dr. Marcia Lynn Whicker, who first introduced it in her 1996 analysis and categorized leadership in organizations into three types: trustworthy, transient and toxic. Whicker (1996) characterizes toxic behaviors of leaders as complaining, vindictive, restless and malicious. Jean Lipman-Blumen later expanded the concept by suggesting that certain leaders exhibit toxic tendencies (Heppell, 2011). According to Lipman-Blumen (2005), toxic leaders are those whose destructive behavior and dysfunctional personality traits cause serious and lasting harm to individuals, organizations, and even the nations they lead. According to him, toxic leaders are managers who do not adopt constructive feedback, encourage approval instead of critically evaluating the leader's judgments and behaviors, and thus harm employees. Flynn (1999) adds that toxic leaders are rude and cruel and exhibit characteristics such as speaking loudly to stakeholders and engaging in hurtful and repulsive behavior.

Toxic school leaders exhibit an authoritarian leadership style that focuses on control rather than collaboration (Dahlan et al., 2024). This approach stifles creativity and discourages open communication, preventing the development of a supportive learning community. Toxic leaders engage in favoritism, giving undue preference to certain individuals or groups (Klahn Acuña & Male, 2024). This not only leads to resentment among staff, but can also undermine the principles of fairness and equity within the educational institution. Micromanagement is also seen as a common feature of toxic leadership (Lipman-Blumen, 2005). Constant interference in the duties of teachers and staff leads to a culture of insecurity. Since educators may feel overwhelmed and demoralized, their professional development will be negatively affected. Toxic leadership occurs as a result of a lack of empathy, and this lack leads the leader to disregard the feelings and needs of others, creating insecurity and stress in the work environment. As Schmidt (2008) points out, toxic leaders tend to ignore stakeholders, lack empathy, and do not prioritize their individual needs, which leads to a loss of organizational trust. In these organizations, it is claimed that individuals who accept everything without question are rewarded, while those who approach things critically, think differently and have creative personality traits are punished by being removed from important positions. According to Lipman-Bluman (2005), toxic leaders expose their followers to humiliation, do not support them, demoralize them, instill fear, take away their rights, limit their abilities and engage in unethical behavior. In addition, they force stakeholders to submit to their authority through threats and withhold information.

Such harmful effects of leaders not only prevent the organization from achieving its goals but also harm its stakeholders (Dahlan et al., 2024).

Research on toxic leadership shows that the negative behaviors exhibited by toxic leaders have detrimental effects on both the work environment and the organizational climate, affecting stakeholders' organizational commitment and trust (Lipman-Blumen, 2005). In other words, there is a direct relationship between the negative leadership attitudes exhibited by managers and the level of organizational trust among employees. In addition, the level of organizational commitment among stakeholders also plays a role in shaping the organizational trust environment. Toxic leadership behaviors displayed by managers not only impact the organizational trust perception of the staff, but also reduce the overall level of organizational trust by eroding organizational commitment (Bozkurt et al., 2020). Toxic leadership behavior reduces the productivity of teachers and negatively impacts the benefit dynamics in organizations (Dahlan et al., 2024). This, in turn, can lead to increased absenteeism and anxiety levels, leading to below-average performance and eventually to the disengagement of education stakeholders.

Teacher Accountability

As a requirement of a global and social system, accountability plays an important role in ensuring success in organizations. For this purpose, various accountability policies targeting schools, teachers, administrators or students have been formulated and implemented (Erdağ, 2020). O'Day (2002) categorized accountability as managerial/bureaucratic, legal, professional and market accountability. Cendon (2000) defined it as political, managerial, professional and democratic accountability. Political accountability involves responsibility in public administration, extending hierarchically up to government leaders and involving the obligations of governments to parliament. Managerial accountability refers to accountability to senior management or external stakeholders for compliance with legal regulations. Professional accountability is linked to adhering to the norms and rules of a particular professional group and performing in accordance with professional standards. Democratic accountability is defined as direct responsibility to the public and fulfillment of the duty of proactive transparency towards citizens (Cendon, 2000). Rosenblatt (2017) conceptualized teacher accountability not only as an attempt to comply with external demands and expectations, but also as a two-dimensional subjective reality that encompasses teachers' professional competence, professional development needs, and professional ethics. Research shows that the concept of accountability is an important factor for organizations as it shows that employees' sense of responsibility affects their well-being, motivation and performance (Erdağ, 2020).

Hoy & Miskel (2010) base accountability in education on three basic principles: (1) Schools should be held accountable for high standards of performance; (2) Schools should be supported to strengthen their capacity to deliver quality education and (3) Schools should improve the rate and quality of performance outcomes, especially student outcomes. Education institutions have defined the accountability framework to include decisions on student performance, inputs and outputs, and various tools and methods to improve achievement in line with the goals set by school staff. In addition, the concept of accountability in education includes all activities, decisions, in-service courses, educational initiatives, and methods and techniques used to increase student achievement in line with the mission and vision of the school (Himmetoğlu et al., 2017; Kalman & Gedikoğlu, 2014; Yıldırım & Yenipınar, 2019). Accountability is often characterized as a process centered on results and outcomes (Türkoğlu, 2015). Therefore, as schools and teachers strive to achieve success by using state resources, they should be scrutinized according to the progress levels of their students (Ertan Kantos, 2010). Thus, it is widely believed that an increase in the perception of accountability in schools is associated with an increase in overall achievement (Himmetoğlu et al., 2017). According to Ingersoll & Collins (2017), considering that teachers are the main actors in school processes, teacher accountability is of great importance. Although each school has its own characteristics, it is an undeniable fact that teachers, as the individuals who are in the closest communication with students, actively shape the classroom environment and assume many responsibilities (Şişman, 2011). The teacher is usually solely responsible for the students in the classroom. Therefore, they are not directly accountable for their behavior and performance. Therefore, it is important for teachers to be accountable for their actions.

Contemporary accountability practices aim to ensure that schools meet the expectations of academic performance mandated by law, bureaucracy and professional standards (Türkoğu, 2015). They are tasked with establishing the necessary mechanisms, ensuring their functioning and improving student outcomes. The ultimate goal is to change teacher behavior to increase effectiveness and efficiency, thereby improving overall school outcomes, especially student academic performance. In this framework, accountability is seen as both external performance expectations placed on teachers and internal systems designed to support teachers' intrinsic motivation and teaching skills (Erdağ, 2020). Teachers not only transfer knowledge, but are also responsible for students' individual development, academic achievement and social skills (Baidoo-Anu & Ennu Baidoo, 2024). In fulfilling these responsibilities, accountability requires teachers to adopt student-centered approaches and adhere to professional ethics (Jena, 2023). This approach builds transparency and trust in educational processes, while also improving the quality of education provided to students (Gore et al., 2023). Teacher accountability is one of the key elements that determine not only individual teaching practices, but also the effectiveness and efficiency of an entire education system.

The Relationship between Toxic Leader Teacher Accountability

Educational organizations are institutions where human interaction is deeply felt. In such situations, leaders recognize the psychological and social needs of individuals and try to meet these needs (Şişman, 2014). For this reason, effective leadership in education is crucial in fostering a positive and productive learning environment (Güçlü & Kılıç, 2011). However, when leadership

becomes toxic, its repercussions can be felt by the entire education system. Toxic leadership is characterized by behaviors and practices that harm the well-being of an organization and its members (Heppell, 2011). In the educational context, toxic leaders may exhibit characteristics such as micromanagement, lack of transparency, favoritism, and failure to provide support and resources. When these characteristics are prevalent in educational leadership, the negative impact on teacher accountability becomes evident (Lipman-Blumen, 2005). One of the primary effects of toxic leadership is the erosion of trust within the school community. When teachers feel that their leaders do not have their best interests at heart or that their efforts are not valued, a culture of distrust can permeate the organization. In such an environment, collaboration and open communication are inhibited, making it difficult for teachers to take ownership of their roles and be held accountable for student outcomes (Cendon, 2000). Toxic leaders often resort to fear-based management strategies, creating an atmosphere where teachers are motivated by fear of retaliation rather than a genuine commitment to student achievement (Heppell, 2011). This fear-based approach to accountability can lead to a culture of compliance rather than continuous improvement. Teachers may hesitate to take risks or implement innovative teaching methods for fear of negative consequences if their efforts are not aligned with the narrow expectations set by toxic leaders (Elmore, 2005). Teacher accountability is closely linked to continuous professional development. However, toxic leadership tends to prioritize budget constraints over investing in educators' growth and development (Baidoo-Anu & Ennu Baidoo, 2024). When opportunities for professional development are limited, teachers may struggle to stay up-to-date with best practices, hindering their ability to adapt to evolving educational standards and methodologies (Himmetoğlu et al., 2017). In general, most government reform initiatives that seek to make schools more accountable assume that principal leadership plays a key role (Padilla et al., 2007). This paper therefore examines how toxic leadership undermines teacher accountability and thus the quality of education provided to students.

Purpose of the Research

The main purpose of this study is to investigate the detrimental effects of school administrators on teacher accountability in the context of toxic leader behavior according to teachers' views and to explore its corrosive impact on teacher accountability with the aim of identifying factors that contribute to improving educational outcomes and potential mitigating strategies. In line with this main purpose, the study sought to answer the following questions;

1. What is the relationship between toxic leadership and teacher accountability?
2. Are school administrators a toxic leader?
3. What is the impact of toxic leader behaviors on teachers?
4. What are teachers' perceptions of teacher accountability?
5. What is the role of toxic leader in teacher accountability?
6. What strategies can be implemented to reduce the corrosive effect of toxic leaders on teacher accountability?

METHOD/MATERIALS

Research Design

Survey model approach was used in the research. This type of research method is typically used to capture the characteristics of a particular situation or event in its current state or as it was in the past. The aim, as stated by Karasar (2006), is to provide a detailed and accurate description of the subject within its natural context. In addition, the study adopted a qualitative research methodology, which was chosen for its effectiveness in providing a comprehensive and nuanced understanding of the topic under study. Phenomenological design, a subset of qualitative research methods, was used in the study. Phenomenology generally focuses on phenomena that are familiar to us but do not have an in-depth and comprehensive thought structure. It is useful in investigating issues that are completely unknown but all their consequences and meanings cannot be fully grasped. The primary data sources in phenomenological studies, as defined by Yıldırım & Şimşek (2008), are individuals or groups who have directly experienced the subject or have the ability to express the subject clearly.

Universe/ Sample

This study was conducted with a total of 20 teachers working in 10 Anatolian high schools in Isparta Central District in the 2023-2024 academic year. The sample of the study was formed by purposeful criterion sampling method from the teachers of ten Anatolian high schools who volunteered for the research (Kıral & Karaman Kepenekçi, 2018). The reason for choosing purposive criterion sampling is that the students participating in the study have knowledge and experience related to the subject. Therefore, it is thought that their contribution to the research is significant. The demographic characteristics of the teachers participating in the study are given in Figure 1. and Figure 2.

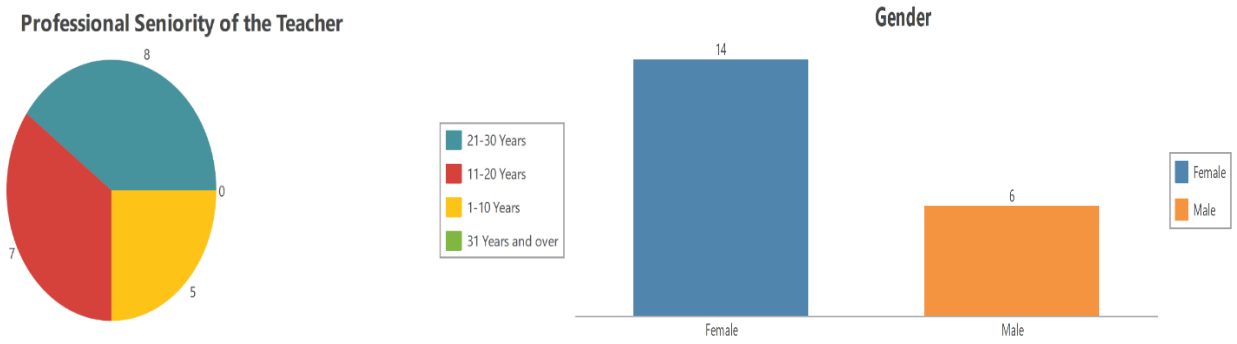

Figure 1. Demographic information of the teachers participating in the study group

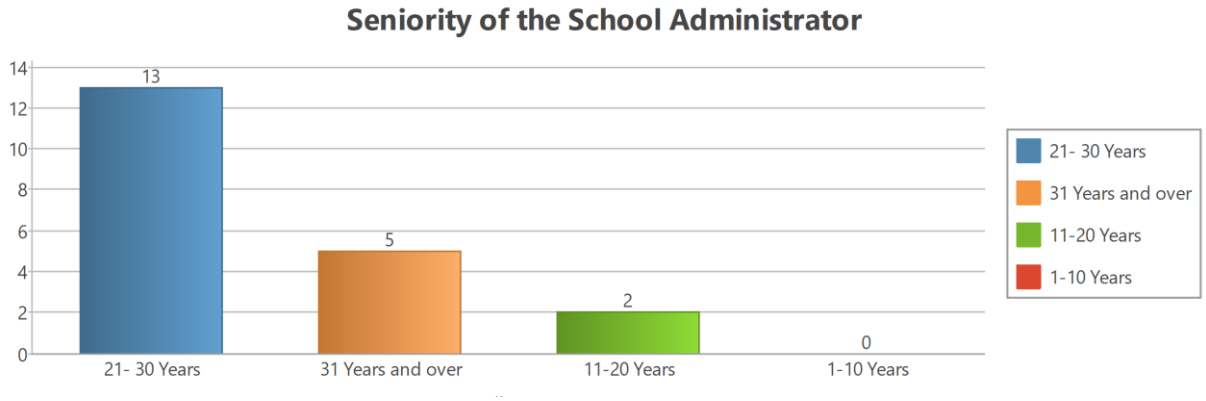

Figure 2. Demographic information of the school administrators of the teachers participating in the study group

As shown in Figure 1, the teachers consisted of 14 women and 6 men. The seniority of 9 teachers participating in the study is 21 years and above, 7 of them are 11-20 years, 4 of them are 1-10 years. In Figure 2, information about the professional seniority of the school administrators of the teachers participating in the study group is given. 13 school administrators' seniority years are between 21-30 years, 5 of them are 30 years and above, and 2 of them are between 11-20 years.

Data Collection Tool

In order to examine teachers' views on the corrosive effect of toxic leadership behaviors of school administrators on teacher accountability, data were collected through a semi-structured interview form. Teachers' opinions were obtained through face-to-face interviews. First, the literature on the subject was reviewed in detail by the researchers. Then, a semi-structured interview form was prepared based on the literature. The questions were examined in detail by taking the opinions of three faculty members who are experts in the field, and the comprehensibility and relevance of the questions were determined. The interview form consists of eight questions:

1.) How would you define toxic leadership? Does your school administrator show toxic leadership behaviors?

2.) What impact do your school administrator's toxic leadership characteristics have on teachers?

3.) How would you define teacher accountability?

4.) How do the toxic behaviors of your school administrator affect your accountability?

5.) To what extent does your school administrator's miscommunication and lack of appreciation as a toxic leader affect your level of internal accountability?

6.) How does your school administrator's toxic leadership affect trust and transparency in your accountability process?

7.) Does your school administrator's resistance to feedback or constructive criticism in your accountability process as a toxic leader affect your academic performance?

8.) What strategies should be implemented to reduce the corrosive impact of toxic leadership on accountability?

Data Collection and Analysis

The research was subjected to an evaluation by using content analysis, one of the qualitative data analyses, with the use of toxic leadership and teacher accountability forms. The main goal of content analysis is to reveal concepts and relationships that can illuminate the data obtained. The basic procedure in content analysis involves classifying similar data under certain themes and interpreting the data within a defined framework that the reader can understand (Ayyıldız & Akın, 2016). The first step in content analysis requires coding the data obtained; this is a comprehensive examination of the data to identify similar sections and to grasp the conceptual meaning of each section. Then, the codes are divided into certain groups, the data are organized according to the codes and themes, and the findings are interpreted and themes are formed (Yıldırım & Şimşek, 2011).

Face-to-face interviews were conducted with willing teachers in their own schools and voice recordings were taken with the approval of the teachers. The opinions of the students who did not accept the voice recording were noted. In this context, the opinions of 2 teachers were recorded using a voice recording system, while the opinions of 18 teachers were documented in writing since they did not prefer voice recording. The teacher interviews lasted approximately 630 minutes. After the interviews, the author explained the verbal and written opinions of the participant teachers in a computerized format. During the presentation of the findings, the participant teachers were coded as T1- T20 (Teacher 1- Teacher 20). The participants between Teacher 1- Teacher 20 consisted of ten Anatolian high school teachers. The responses obtained were analysed in four stages. These stages are; coding the data, finding the themes, categorizing and defining the data according to the codes and themes, and finally interpreting the findings.

Validity and Reliability Studies

Studies were conducted to ensure the validity and reliability of the research and data analysis stages. In order to increase validity, the data obtained were examined in detail and reported. In addition, direct quotations from the students included in the study were used to increase validity. The possibility of obtaining detailed information about the subject through face-to-face interviews, the possibility of going back for the accuracy of the findings and obtaining additional information also increases the validity rate. Considering the generalizability of the research results to similar environments, it can be said to have external validity (Akın, 2016). In the first stage of the research, codes were created deductively, and then sub-codes were created inductively. In the last stage, categories were formed in line with the codes and sub-codes (Akın, 2016).

As a result of the research, the reliability of the findings was assessed by three experts using the formula suggested by Miles & Huberman (1994): "(Reliability: [Agreement / (Agreement + Disagreement) x 100])". As a result, 90% of the experts agreed and reached a consensus.

FINDINGS

Teachers were interviewed about the corrosive effect of toxic leadership on teacher accountability in schools. Based on the findings of the analysis, the findings from the study were categorized into five main themes about teachers' views on the impact of toxic leadership on teacher accountability.

Figure 3. Word cloud of teachers' views on toxic leadership and teacher accountability

A word cloud was formed from the most frequently expressed words within the scope of teachers' views on the corrosive effect of toxic leadership of school administrators on teacher accountability. The word "toxic" was repeated 30 times, the second word "negative" was repeated 29 times and the third word "account" was repeated 28 times.

Teachers' Views on Toxic Leadership of School Administrators

Within the scope of the research, teachers working in 10 Anatolian high schools were first asked whether school administrators exhibit toxic leadership behaviors. As presented in Figure 4, a graph was presented in the form of yes or no regarding the toxic leadership of school administrators. In this graph, 16 participant teachers answered no and 4 participant teachers answered yes.

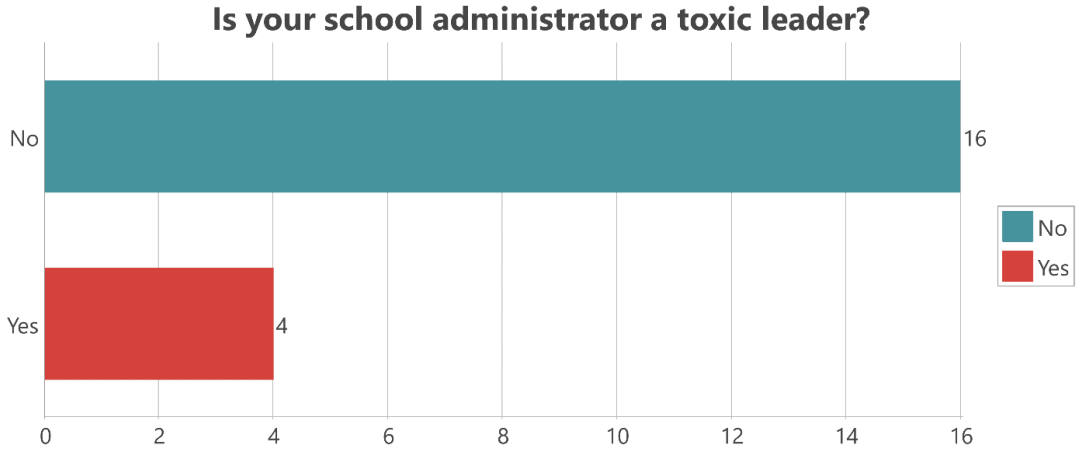

Figure 4. Table showing toxic leadership of school administrators

According to the results obtained, 4 participants stated that school administrators showed toxic leader behavior. Under the theme of yes, 3 sub-themes were formed. These are controlling, lack of transparency and negative organizational climate. Among the most frequently mentioned topics, there are codes related to school administrators creating controlling and negative organizational climate.

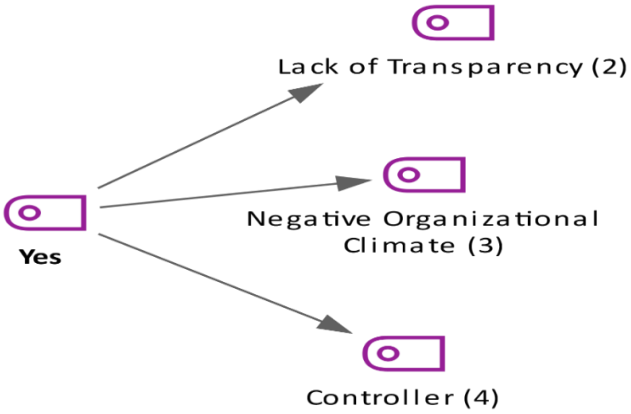

Figure 5. Classification of teachers' views on toxic school administrators

Below are the codes related to the meanings experienced and reported by the teachers and sample quotations for each code.

Lack of Transparency

As a result of the research, teachers stated that school administrators were not transparent as toxic leaders and some issues were kept secret. Teachers shared their experiences about this issue as follows:

"I think he is not transparent, some things are kept secret, and he does not share them with us." (T1)

"I think it is not transparent, it is not clear enough." (T11)

Negative Organizational Climate

Teachers stated that school administrators created a negative organizational climate by showing toxic behaviors, harmed the cooperation between school stakeholders and engaged in offensive behaviors. Teachers' views on this issue are as follows:

"Due to excessive supervision, it does not have an equal effect on the employees and causes deepening of groupings in the environment. It disrupts the relationship between friends and tries to isolate people." (T1)

"It has a negative effect. They show offensive behaviors in public. This affects the working environment negatively." (T13)

Controller

Within the scope of toxic leadership behavior, teachers stated that school administrators behaved in a controlling manner the most. They stated that school administrators intervene in everything from the teachers' entry and exit times to the documents they bring to the class and that they do not want any step to be taken without their knowledge. Teachers' views on this issue are as follows:

"We have an overly controlling and perfectionist school administrator. He follows every step we take." (T10)

"He has an attitude that is too interventionist and controlling, and hardens when what he wants is not realized." (T11)

Teachers' Views on the Effects of Toxic Leader Behaviors on Teachers

The questions asked to the teachers about the impact of toxic leadership of school administrators on teachers revealed the codes under the theme of the impact of toxic leadership on teachers presented in Figure 6. These codes were divided into four groups as negative situation and self-regulation. The negative situation sub-theme was also divided into four categories. These are inefficiency, passivity, psychological pressure and alienation. As can be seen in Figure 6, passivity and psychological pressure categories are the most frequently mentioned issues.

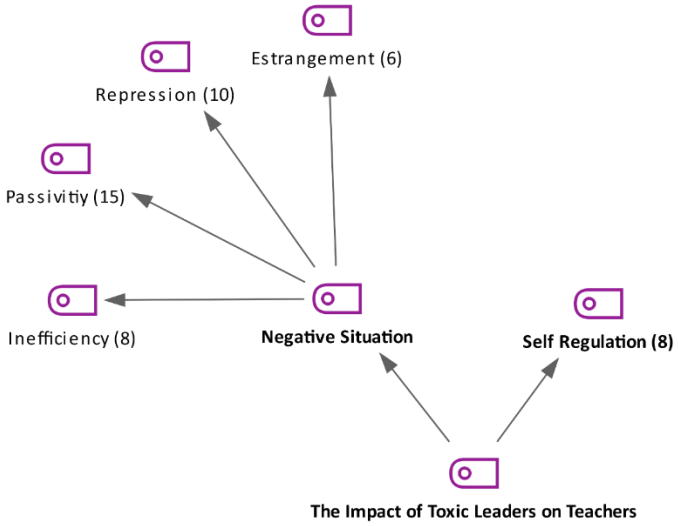

Figure 6. Classification of teachers' views on the effects of toxic leaders on teachers

Negative Situation

Toxic leader behavior can lead teachers to negative situations in many ways. Within the findings, the negative situation theme was divided into four sub-themes; inefficiency, passivity, psychological pressure and not feeling belonging. The most frequently mentioned issue in the negative situation theme is the sub-theme of passivity. Teachers stated that the fact that school administrators were toxic leaders caused reluctance in teachers, decreased commitment to school, unwillingness to work and distancing. Secondly, the sub-theme of psychological pressure was mentioned the most. Teachers stated that they entered into a negative psychological state within the scope of toxic leadership behavior. They stated that they could not be comfortable because they felt that they were constantly under surveillance, that they were humiliated even in a minor incident and that they could not be peaceful for these reasons. In the sub-theme of inefficiency, teachers stated that toxic behavior of school administrators would decrease productivity. They stated that their creativity would be hindered because they would be negatively affected by toxic behavior, they would be timid when implementing a new idea because of toxic behavior, and therefore they would not update themselves. In the alienation sub-theme, teachers stated that they would move away from the school and school stakeholders, become alienated and weaken their sense of belonging due to toxic behaviors. Teacher views on these sub-themes are as follows:

"Since it will create an unhealthy working environment, I will come to school reluctantly and become a teacher who only wants to do his/her job and escape. In the educational environment, especially such situations will primarily affect the students and bring along many negative problems." (T7)

"I definitely do not make an extra effort outside my duty. A teacher has many more duties than attending the lesson. I do not take part in any of these." (T15)

"The fact that teachers and other employees feel that they are under surveillance creates a feeling of psychological pressure and discomfort." (T12)

"I avoid using new methods and techniques in the lesson because it would decrease my motivation. This prevents me from updating myself as a teacher and I cannot provide efficiency to my students." (T3)

"The negative climate of the school environment can reduce my working efficiency, I cannot realize my new ideas and my creativity is hindered." (T1)

"I do not feel that I belong to the school and I move away." (T9)

"I get cold from school. I don't want to come." (T17)

Self-regulation

Some of the teachers, on the other hand, stated that they were not affected by the toxic behaviors of school administrators, that they protected themselves from toxic behaviors and that they were able to re-motivate themselves by self-regulation. Teachers' opinions on this issue are as follows:

"I try to move forward by re-motivating myself in terms of self-renewal, enjoyment (of the work), the pleasure of being able to teach new things to students. If informal accountability provides you with positive feedback, this increases your strength, and you continue on your way." (T1)

"Aiming to fulfil the necessity of the profession by making a logical and conscientious accounting by ignoring the corrosive effect of the toxic leader, not making concessions to the toxic leader." (T8)

Teachers' Perceptions of Teacher Accountability

Teachers' perceptions of the concept of teacher accountability were divided into two sub-themes: internal accountability and external accountability as shown in Figure 7. The internal accountability sub-theme was categorized as conscience. The external accountability category was coded as responsiveness.

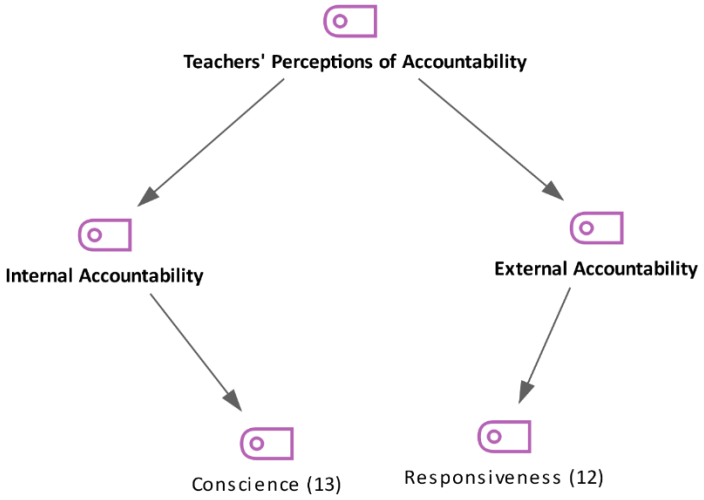

Figure 7. Classification of teachers' views on teachers' accountability perceptions

Internal Accountability

The theme of internal accountability was divided into the sub-theme of conscience. Teachers defined the conscience code as being conscientiously comfortable with the behaviors of teachers within the scope of their duties. They mentioned the requirements of their profession and being responsible for student success. Teacher opinions on this theme are as follows:

"First, I am accountable to myself so that my conscience is comfortable. Therefore, whether my school administrator is toxic or not does not affect my accountability at this point."(T4)

"The most beautiful accountability of the teacher is the smiling eyes of the students. I recognize no mechanism other than my conscience." (T15)

"To do his/her job according to the legislation and moral principles and not to refrain from expressing what he/she did and did not do with his/her deficiencies and mistakes when asked." (T11)

External Accountability

The teachers coded the concept of external accountability as responsiveness. They defined accountability as giving an account of what they did to the authority during the supervision. The opinions supporting these ideas were stated as follows:

"Being able to evaluate the results of his/her lessons or social and cultural activities." (T18)

"It is the supervision of a teacher against external authority about his/her lessons and responsibilities and the teacher's ability to respond to these supervisions." (T5)

Teachers' Views on the Role of Toxic Leader in Teacher Accountability

As a result of the findings, teachers' views on the role of toxic leaders in teacher accountability were divided into two themes: negative impact and resilience. As seen in Figure 8, the themes of lack of motivation and insecurity were among the most frequently mentioned issues.

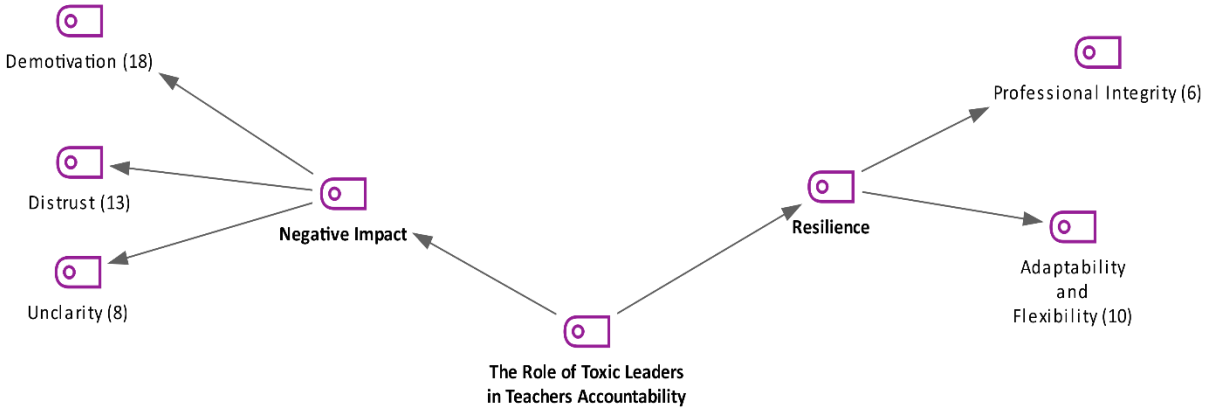

Figure 8. Classification of teachers' views on the role of toxic leader in teacher accountability

Negative Impact

The negative impact theme was divided into three sub-themes: lack of transparency, lack of motivation and insecurity. Lack of motivation was the most frequently mentioned sub-theme in line with teachers' opinions. Toxic behaviors of school administrators cause a decrease in teachers' motivation. This significantly affects the academic performance of the teacher. It is concluded that they are negatively affected both academically and in terms of classroom effectiveness. The insecurity sub-theme was the second most frequently mentioned issue. Teachers stated that they lost their trust in school administrators in the face of toxic behaviors and therefore did not want to communicate with them. In the sub-theme of not being transparent, teachers stated that they could not be transparent to school administrators in the accountability dimension because they did not trust the toxic leader and could not express everything openly. The opinions supporting these thoughts are as follows:

"Of course it modifies my trust negatively. This increases in proportion to the severity of the negativity experienced. " (Ö19)

"It might have been more difficult to be transparent in the face of school administrators who exhibit pressure and intimidating behaviors. The existence of an environment of mutual trust and confidence in a school can help us to be comfortable and more transparent in the process." (S8)

Resilience

Teachers' views were divided into two sub-themes under the resilience sub-theme: professional integrity, adaptability and flexibility. As seen in Figure 8, adaptability and flexibility were the most frequently mentioned topics. Most of the teachers stated that the toxic behaviors of school administrators did not affect their academic performance and teaching. In this way, it can be concluded that they were able to adapt themselves to the situation and show flexibility. They stated that they further strengthened themselves and increased their accountability dimensions by updating themselves in line with technological developments. As for professional integrity, they stated that working under toxic leadership is emotionally and mentally exhausting, but teachers' continuing to fulfill their duties effectively and fulfilling their obligations internally and externally will increase their resilience and they will be able to stand upright in the face of toxic leaders. Teacher statements supporting the views are as follows:

"As a teacher, I question my accountability not according to a toxic administrator, but within the framework of the rules required by my profession and in a way that I can be accountable to my own conscience." (T8)

"Since I do not do my job for someone else to inspect, the behavior of the toxic leader cannot affect my academic performance and accountability. I do my job." (T18)

"I complete the tasks required by my duty, complete the documents, and do not interfere too much. I take myself under protection." (T6)

Teachers' Views on Strategies to Mitigate the Toxic Leader's Corrosive Effect on Teacher Accountability

The strategies that should be implemented in order to reduce the corrosive effects of school administrators' toxic leadership behaviors on teacher accountability were classified into two themes in line with teachers' views. These themes are self-awareness and legislation. As a result of the interviews, self-awareness was the most pronounced theme.

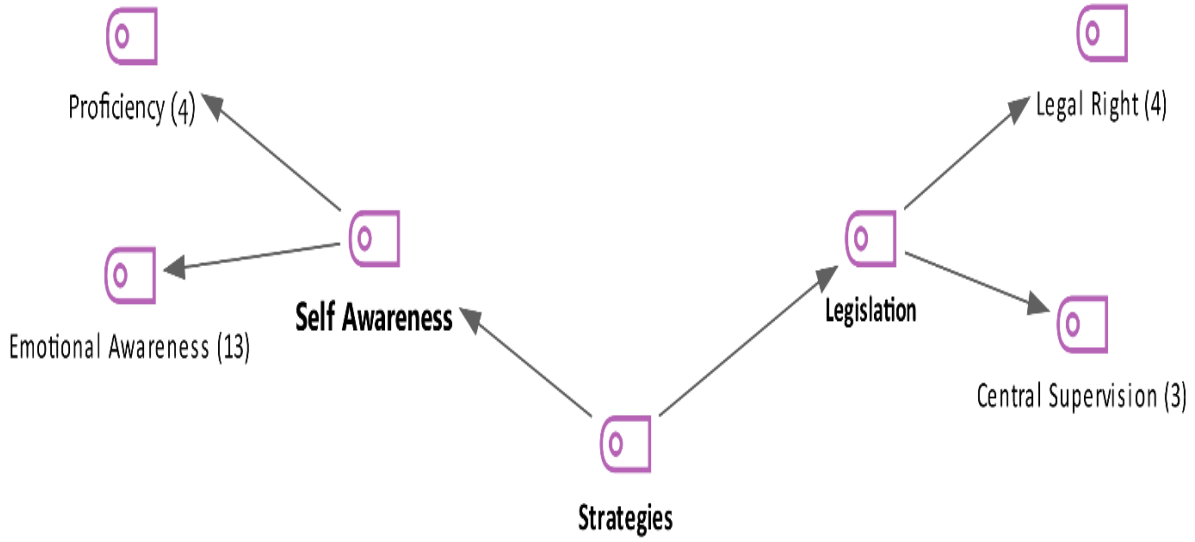

Figure 9. Classification of teachers' views on strategies to mitigate the corrosive effects of toxic leaders on teacher accountability

Self Awareness

The self-awareness theme was divided into two sub-themes: competence and emotional awareness. The most frequently mentioned theme was emotional awareness. Teachers stated that school administrators should be made emotionally aware of the fact that they show toxic behaviors. They stated that they should be made aware of how to solve this issue and create affective awareness by giving feedback through the questionnaire or by communicating with them and explaining how they behave. They also stated that school administrators should be enabled to empathize and allowed to develop their affective intelligence. In the sub-theme of competence, opinions were expressed that school administrators should create personal awareness by developing themselves not only in cognitive but also in affective terms. Teachers shared their opinions on this issue as follows:

"First, toxic behaviors of school administrators should be prevented, and they should be made aware of this issue. MEB should conduct research on administrator behaviors at certain intervals in schools. Awareness is the beginning of everything. If awareness is created, school administrators can criticize and correct their behaviors. Thus, the corrosive effect can be reduced or eliminated." (T4)

"The competence and emotional intelligence of school administrators are very important not only in terms of legislation but also psychologically." (T13)

"Not everyone should be appointed as school administrators. People who are educated, self-realized and competent in every sense should be brought to management." (T16)

Legislation

The legislation theme consists of two sub-themes: legal rights and centralized supervision. Teachers stated that school administrators showing toxic behavior should be centrally audited by the Ministry of National Education at certain intervals. However, these inspections should not only be documented, but also the psychological soundness of the school administrator should be questioned. In the legal rights sub-theme, teachers expressed the opinion that teachers should know their personal rights well and apply to the necessary authorities when faced with toxic behaviors. In this regard, teachers expressed their opinions as follows:

"First, in order to prevent the emergence of such leaders, a system of checks and balances should be provided. Central control activities should be carried out at certain intervals." (T10)

"It would be a good strategy to know our personal rights and legal obligations well and not to hesitate to seek our legal rights when necessary." (T5)

"The units that will implement this are the higher units. We teachers can only report this to the higher units and seek our legal rights." (T7)

DISCUSSION

Administrators are an important element in shaping the culture and success of educational institutions. However, when leadership becomes toxic, the consequences can be corrosive, especially in terms of teacher accountability. When teachers feel that their leaders are not interested in their welfare or that they are being blamed without taking a broader view, their trust is destroyed. The result is a fragmented school community where collaboration is inhibited and teachers can become reluctant to

take risks or share innovative ideas. Toxic leadership, which affects many areas in this way, has a corrosive effect on teacher accountability by creating an atmosphere of fear and vulnerability.

As a result of the findings, it was determined that most of the school administrators did not show toxic leadership and some of them showed toxic leadership behaviors. The behaviors of school administrators as a toxic leader were coded as controlling, lack of transparency and negative organizational climate. Controlling behavior of school administrators creates anxiety and discontentment among teachers. Their controlling nature permeates every aspect of the educational experience, from stifling academic creativity to inhibiting teacher autonomy. Toxic leaders often show favoritism, creating a climate of competition and resentment among teachers. Personal biases can influence decisions about evaluations, creating a culture of distrust and division within the school community. Toxic leaders who work in secrecy, wield power behind closed doors and keep their followers in the dark demonstrate a deliberate lack of transparency, hiding their goals, decisions and actions from teachers. Lack of transparency fosters speculation, undermines trust and breeds suspicion. Trust, an important element of a successful school environment, is eroded when employees feel they are kept in the dark about decisions that directly affect them. As teachers lose faith in a leadership style that values confidentiality more than openness, their sense of belonging disappears. As toxic leaders, school administrators create a negative organizational climate. Communication breaks down, information flows unidirectional from top to bottom, and employees feel disconnected and uninformed. The lack of open dialogue leads to misunderstandings, rumors and a pervasive sense of uncertainty. Collaboration becomes challenging in this environment where employees are afraid to share ideas or collaborate for fear of punishment. Moreover, toxic leaders often exhibit favoritism and divisive behavior, creating factions within the workforce. This leads to resentment, demotivation, and feelings of injustice, undermining morale and team cohesion. The results of the research reflect the results of previous studies. Dobbs (2014) stated that employees perceived their leaders as exhibiting low levels of toxic leadership behaviors. In another study, when teachers' average perceptions of toxic leadership were evaluated, it was concluded that school principals exhibited low levels of toxic leadership behaviors. Therefore, based on the findings of this study, it can be argued that teachers mostly do not perceive principals' leadership behaviors as toxic. This result overlaps with the results of Demirel's (2015) study conducted with a sample of teachers and is consistent with İzgüden et al.'s (2016) study conducted with health personnel. In contrast to these results, Green's (2014) study focusing on toxic leadership in educational organizations revealed that 90% of educators reported that they encountered toxic leaders. When the international literature is examined, it is seen that employees generally perceive their managers as people who exhibit toxic leadership characteristics.

The category of teacher perceptions of the concept of accountability is divided into two codes: internal and external accountability. An important component of intrinsic accountability is not only meeting professional standards or legislative requirements, but also ensuring that teachers fulfill their duties with a clear conscience. A clear conscience in teaching involves making ethical decisions that put the interests of students first. Having a clear conscience also involves a commitment to continuous reflection and improvement. Teachers should regularly evaluate their teaching methods, identify areas for improvement and actively seek opportunities for professional development. This proactive approach helps to ensure that educators remain effective and responsive to the evolving needs of their students. Teachers' transparency in accountability creates an environment where trust flourishes, fostering a sense of shared responsibility for student achievement. Transparent teachers contribute to a positive and collaborative learning community by actively engaging with students, parents and colleagues through open communication and clear practices. Teachers described accountability as being able to answer to external authorities about their authority and responsibilities. Teachers are accountable for their teaching practices and supervision provides a mechanism for administrators or mentors to observe and evaluate these practices. Supervision involves ensuring that teachers comply with school policies, curriculum guidelines and educational standards. Responsiveness to supervision is an important component of teacher accountability and demonstrates a commitment to continuous improvement and a collaborative approach to achieving educational goals. According to Bakioğlu & Sanduz (2014), teachers emphasized that course audits should be conducted by other stakeholders rather than school administrators. Koçak et al. (2012) argued that supervision of teachers from external sources is not sufficient in terms of supervision processes and that it is difficult to adopt such a form of supervision due to the increase in administrative workload. Erdağ & Karadağ (2017) emphasized the importance of active participation of school principals in supervision to instill accountability among teachers. Erdağ (2013) found that the above-mentioned differences in approach are managed differently according to the type of school, and that there is a relationship between the role undertaken and the degree to which the sense of accountability is felt. Himmetoğlu et al. (2017) explained the accountability of school administrators with concepts such as transparency, information provision and responsibility. They also argued that accountability plays an important role in issues such as school choice and success. These findings support the external accountability aspect of the study because in this dimension, teachers basically perceive themselves as accountable with an orientation towards success. Koçak & Sezgin Nartgün (2018) concluded in their study that teachers' perceptions of internal accountability are at the forefront. Similarly, Altıparmak (2019) reported teachers' positive responses to the accountability scale in line with the research results.

The category of teachers' views on the role of toxic leaders in teacher accountability was categorized as negative impact and resilience. The negative impact code was sub-coded as lack of transparency, lack of motivation and insecurity. Teachers stated that school administrators could not be open and clear in the face of toxic behaviors and could not express everything transparently. In addition, it was observed that teachers' motivation decreased as a result of destructive and negative criticisms of toxic leaders. Without a foundation of trust, teachers can become demoralized and less responsible for their actions. The resilience code refers to educators' ability to maintain commitment to their professional responsibilities, adapt to challenging

circumstances, and persevere in the face of unfavorable leadership conditions. Resilient teachers maintain their professional standards and ethical principles even in the face of toxic leadership. Resilient teachers show adaptability and flexibility in their teaching approach. It can be interpreted that despite toxic leadership, they find creative ways to overcome challenges, adjust their strategies and meet the needs of their students while taking responsibility for their role. According to the conclusion reached, leadership types have various effects on teacher accountability. Kandemir & Akgün (2019) concluded that the presence of servant leadership qualities in a school administrator encourages a positive impact on the school environment by leading to increased accountability among teachers.

The category of teacher views on strategies that should be implemented to reduce the corrosive effect of toxic leader behaviors on teacher accountability was divided into two codes. These codes are personal awareness and legislation. Increasing personal awareness of toxic leaders in schools is crucial to empowering educators to recognize, respond to, and deal with toxic leadership behaviors. Organizing workshops and training sessions to educate school administrators on the characteristics of toxic leadership, and raising their awareness with examples and case studies to help them understand how toxic leadership can manifest in educational settings was emphasized. In addition, establishing a formalized feedback mechanism for teachers on their leadership practices and regularly reviewing this feedback to identify patterns and areas for improvement is identified as an element that can help reduce the corrosive impact on teacher accountability. Teachers expressed the need for legislation to provide legal recourse for teacher accountability that is undermined by toxic leadership. This should include the ability to file a complaint, seek compensation, or take legal action against leaders who engage in harmful behavior. Legislation should outline a process for institutions to intervene and provide support or oversight where toxic leadership is identified. It is important to note that the effectiveness of legislation depends not only on its content but also on implementation, enforcement and ongoing evaluation. Teachers, administrators, policymakers, and community members collaborating to ensure that legislation effectively addresses and prevents toxic leadership in educational settings is interpreted as helping to reduce the corrosive impact of toxic leaders on teacher accountability. In Kandemir & Akgün's (2019) study, it was stated that school administrators have a positive impact on the school when they exhibit behaviors such as accepting that their authority stems from their position rather than their personal identity, seeing themselves as equal to others, and avoiding seeing themselves as more talented than their peers. Salduz (2013) emphasized in his study that it is very critical for school administrators to initiate transparent and effective communication in order to increase teachers' dedication.

CONCLUSION

The research showed that teacher accountability is a critical element for educational quality and student achievement and can be threatened by toxic leadership. It has increased awareness of the concept of accountability and raised consciousness about the need to protect this concept. Overall, our study highlights the critical role of leadership behaviors in education for the Turkish education system and reveals how significant avoiding toxic leadership is for teacher performance and student achievement. It reveals that toxic leadership has a devastating impact on teachers, severely damaging their motivation, professional commitment and thus their accountability. Under toxic leadership, teachers face negative experiences such as exclusion from decision-making, constant criticism and feelings of worthlessness. This reduces teachers' willingness to take responsibility for the success of their students and jeopardizes the quality of education. Teachers reported a lack of trust and support under toxic leadership, weakening their commitment to maintaining professional standards and providing the best education for their students. These results suggest that the quality of leadership in the education system has a direct impact on teachers' accountability. Therefore, establishing a culture of positive leadership and supportive management in educational institutions is a critical requirement to increase teacher accountability and improve the overall quality of education.

RECOMMENDATIONS

To combat the harmful effects of leaders who lack transparency, organizations need to prioritize a culture of openness and accountability. Leaders must actively share information, encourage dialogue and embrace feedback as a catalyst for growth. By fostering an environment where transparency is valued, organizations can break down the barriers created by toxic leaders and pave the way for a healthier, more collaborative workplace. By doing so, they can rebuild trust, empower their teams and lead the organization towards a more transparent and sustainable future. To counter the corrosive impact of toxic leadership on teacher accountability, it is imperative that educational institutions prioritize a culture of support, open communication and empathy. Leadership development programs should emphasize the importance of emotional intelligence and creating a collaborative and positive work environment. By fostering a climate where teachers feel valued, heard and empowered, educational institutions can reduce the harmful impact of toxic leadership and enable teachers to fulfill their important role in shaping the next generation.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, author-ship, and/or publication of this article

Statements of publication ethics

We hereby declare that the study has not unethical issues and that research and publication ethics have been observed carefully.

Researchers' contribution rate

The study was conducted and reported with equal collaboration of the researchers.

Ethics Committee Approval Information

It has been approved with the decision of Süleyman Demirel University Social and Human Sciences Scientific Research and Publication Ethics Committee, numbered 149/ 33 and dated 20.05.2024.

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