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

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Önsöz

Herkese Merhabalar,

On on yedinci yılımızın ikinci sayısında toplam 10 makale yer almaktadır.

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

Saygılarımla.

Editör

Dr. Gülcan ÇETİN

Preface

Greetings to everyone,

In this edition of our journal, we have a total of 10 articles related to science and mathematics education.

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

Editor

Dr. Gülcan ÇETİN

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Research Article

The Effect of Gamified and Blended Modules on English as a Foreign Language Learners' Language Skills*

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Abstract – Gamification is among the trendiest topics in the context of English language teaching. Despite numerous studies on the impact of gamified language learning, further research is essential to comprehend its dynamics across diverse contexts. Therefore, this study aimed to explore high school language learners' certain language skills after seven weeks of gamified and blended language learning experience. A mixed-method research design was employed to understand the impact of gamified content on learners' reading, vocabulary, grammar, and writing skills. Students' reading, vocabulary, and grammar skills were measured with proficiency tests administered before and after the intervention whereas their writing competence was investigated through grading their written assignments. In addition, learners' opinions regarding the experience were collected to relate the statistical findings to qualitative data. As a result, it was found that the gamified learning experience improved language learners' language skills and learner opinions explained these outcomes adequately.

Keywords: blended learning, English as a foreign language, gamification, language skills.

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Introduction

Gamification is the involvement of components that belong to playful states and serious games within the boundaries of solemn situations such as business, marketing, education, etc.

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* This study is based on the Ph.D. dissertation by Güzel (2023) completed at Çanakkale Onsekiz Mart University, which was supported by the TUBITAK 2211 Domestic Graduate Scholarship program.

to alter the behaviors of target groups for consumption or motivation purposes (Deterding et al., 2011a, 2011b, 2013). It is common to see the integration of game elements in many things in daily life. Collecting points or stars to earn free food or drinks in certain applications is the most obvious example of gamification (Nacke & Deterding, 2017). Nowadays, gamifying various content has become a widespread interest of entrepreneurs or even educators to raise motivation and engagement levels of target audiences (Miller, 2013). It is possible to see gamified platforms and classroom activities enriched with game elements more often because it is a promising technique to awaken learners' interest in the lesson and raise their motivation (Danelli, 2015; Devers & Gurung, 2015; Herzig et al., 2015; Landers et al., 2015).

In connection, it is acknowledged that the language skills of English as a Foreign Language (EFL) learners are well-researched in numerous contexts and settings (Apel & Werfer, 2014; Collins, 2010; Hu, 2012; Huifen & Tsuiping, 2007; Valizadeh, 2022). However, it is indicated that the trial of new approaches and techniques is always encouraged due to the dynamic nature of language learning and technological advancements (Howard et al., 2021; Mestan, 2019). For this reason, educators and policymakers alike have been attempting to come up with effective ways to teach students and equip teachers with useful online skills (Huifen & Tsuiping, 2007; Murphy, 2007). This has paved the way for additional online learning practices adopting new technological integrations (Aydın, 2010; Özdemir & Aydın, 2015).

Receptive skills such as vocabulary and reading set the foundation for the development of EFL learners' language skills in general. In principle, learners of the English language need to extend their vocabulary and lexical depth as well as comprehend the texts and become prominent in their first language (L1) basic language skills to be able to successfully produce the language (Brown et al., 2011; Kahn-Horwitz et al., 2005; Kieffer, 2012; Krashen, 1989; Sze, 1999). Krashen (1989) stated on the matter that vocabulary learning and accurate spelling can be best achieved through reading authentic language sources. In addition, Sze (1999) suggested that as the interest of learners in reading, in general, was reported to decline, tasks requiring extensive reading would provide EFL learners with opportunities to develop language skills, which supported Krashen (1989).

In the sense of vocabulary and reading skills, Roberts and Neal (2004) suggested that the vocabulary of EFL learners can be expanded with the extensive support and direction of the teacher as well as working with groups in small numbers. Literacy levels of EFL learners also play an important role in the reading skills of language learners. To hone the vocabulary and reading skills of EFL learners, Kieffer and Lesaux (2007) proposed that teaching morphological techniques to EFL learners improves their chances of expanding their vocabulary, extracting desired meaning from texts, and comprehending reading texts better.

Sidek (2012), and Konstantakis and Alexiou (2012) reported certain problematic areas in terms of reading and vocabulary learning. In the Malaysian EFL context, Sidek (2012) reported that the Malaysian EFL curriculum for secondary-level education included reading activities that required learners to process information in the texts as they read and complete tasks related to the texts, which did not meet the standards for communicative language teaching models. For this, it was suggested that adding collaboration and communicativeness in the reading instruction would improve the reading skills of EFL learners more effectively. On the other hand, regarding the profile of vocabulary course books of EFL learners of young ages, Konstantakis and Alexiou (2012) found that books did not meet the necessary standards to equip learners with the necessary vocabulary. Considering this might be an issue for other contexts, it was proposed that the use of multiple course books to cover vocabulary would increase the quality of vocabulary acquisition.

Concerning the techniques to use for developing reading and vocabulary skills, Hu (2012) pointed out that fast-mapping tasks can enable students to obtain new vocabulary based on their initial mental word pools. Hu (2012) found that presenting unknown words in sentences beforehand can enable learners to match unfamiliar words to shown objects. In addition, rich definitions provided for new vocabulary increase the number of understood words in a text. These explanations can be made through gestures, definitions, statements out of context, synonyms of the words, and support by visuals and illustrations (Collins, 2010). On another note, Hsieh (2011) proposed that using established sequences and habitual tasks in the classroom improves the likelihood of learning the language. Additionally, depending on the ages of learners, introducing games and fun activities to language learning is beneficial for the learners.

Aside from the aforementioned techniques, methods, and approaches, Huifen and Tsuiping (2007) and Murphy (2007) advocated the use of multimedia tools and online platforms to enrich vocabulary and reading instruction. Murphy (2007) discovered that when the reading comprehension activities were presented on online platforms, elements such as feedback, online interaction, and pair-work can improve the reading comprehension levels of EFL learners. Similarly, Huifen and Tsuiping (2007) attempted to determine the effects of multimedia tools such as animations, visuals, and question prompts as supports for the visuals on learners' reading comprehension. Contexts and questions accompanying the visuals or animations to invoke reading comprehension are necessary for learners.

Considering the writing skills of EFL learners, studies attempting to increase writing through the implementation of different techniques were presented. These studies report their findings of how their techniques affected the writing skills of EFL learners. The methods and techniques used to develop the writing skills of EFL learners in these studies are portfolios, blogging, wikis, morphology training, reviews and feedback, online learning, photographs, social media, collaboration, and literary works (Apel & Werfel, 2014; Aydin, 2010; Espinoza-Celi & Pintado, 2020; Kayacan & Razı, 2017; La Sala, 2018; Mazhar Hameed, 2021; Özdemir & Aydın, 2015; Savran Celik & Aydin, 2016; Valizadeh, 2022; Walter et al., 2019). Prior to discussing the repercussions of such methods and techniques, though, how EFL learners perceive the writing skill should be laid out.

Regarding the attitudes toward the EFL writing process, Aydın and Başöz (2010) revealed that pre-service teachers had positive attitudes toward writing activities in the EFL context. They valued feedback from peers and teachers, and the chance of making revisions. On another note, Duruk (2021) reported that consensus indicated the difficulty of writing skills. The participants found writing as the second easiest skill after reading.

In terms of methods and techniques used to improve writing skills of EFL learners, firstly, Aydin (2010) reported that portfolios were found to be effective in improving mechanics of writing such as paragraph development, essay writing, punctuation, etc. However, it was evaluated as a tiresome and dull process by participants, and it limited the creativity of learners due to the necessity to follow certain rules of writing. Similarly, as a process-based approach to writing, Özdemir and Aydin (2015) implemented blog writing activities and improved the achievement of EFL learners in writing skills. Thanks to this approach, the mechanics of writing were comprehended more thoroughly. However, using blogs did not particularly yield a superiority over conventional writing. One of the main reasons for this could be the technical difficulties faced by learners when using online tools. It can be inferred that using process-based approaches as in Aydin (2010) and Özdemir and Aydin (2015) for teaching writing mechanics can lead to boredom or technological barriers.

In another process-based writing study, Savran Celik and Aydin (2016) discovered that the use of wikis as a process-based writing activity provided more success for EFL learners compared to conventional writing activities. Moreover, Kayacan and Razı (2017) stated that integrating technology into writing instruction in the EFL context mainly produced potent outcomes, revealing that using self-reviews and peer feedback in online platforms led to an increase in EFL learners' writing performance. Digital platforms and anonymity offered a promising mix to develop the writing achievement of language learners.

In another study, La Sala (2018) found that learners turned to different learning styles in the online platform when provided with independence opportunities. Accordingly, the content and task must be meaningful for learners to instigate sufficient work. Independent work on writing activities in an online platform mostly requires a rich and wide array of materials and resources provided by the teacher.

To continue with technological tools and online platforms, Espinoza-Celi and Pintado (2019) noted that Twitter as a language learning platform was regarded as a good way of improving writing skills by most learners. In terms of language learning and teaching, in particular, Twitter use increased learners' achievement levels. However, interest issues may pose a threat to the inclusion of everyone in the classroom willingly. Moreover, according to Valizadeh (2022), the use of collaboration and digital tools provided more positive contributions to learners in EFL writing activities thanks to online feedback and collaboration on a digital platform.

Gamification in the context of EFL is still a new concept and the number of empirical studies providing accounts of qualitative analysis is quite limited, which makes it difficult to reach generalizations and theoretical bases (Azzouz & Guiterrez-Colon Plana, 2020). Even though available studies on the effect of gamification on EFL learners' language skills revealed valuable insights into the issue (Flores, 2015; Hernández-Prados et al., 2021; Pham et al., 2021; Selvasli, 2018; Samosa et al., 2021; Yavuz et al., 2020), it is still difficult to observe a consensus over how game elements can be implemented effectively in EFL contexts. Regarding this, Baldauf et al. (2017) and Hamari et al. (2014) suggested that empirically designed, long-term, and mixed-method studies are constantly required in the field.

As an example of gamified studies, Alharthi (2020) found that Kahoot, FlipQuiz, and similar analog game elements used in language teaching can increase skill achievement. However, such elements can cause learners to lose their focus and act for the sake of rewards because such elements only nurture behavioristic dynamics.

On the other hand, Flores (2015) revealed that gamified environments affect the language skills and social interaction quality of learners positively while Hernández-Prados et al. (2021) found that language learners favored gamified activities over conventional face-to-face lessons. In addition, Pham et al. (2021) explored that game elements combined with mobile applications increased language learners' achievement levels. Similarly, Selvasli (2018) attempted to investigate EFL learners' homework engagement and motivation levels in a gamified learning environment, which indicated positive developments in learners' willingness to complete their assignments and their language competence.

On a skill-level investigation, Purgina (2020) found that game elements offered immense opportunities for learners to improve their grammar skills. Moreover, Samosa et al. (2021) and Yavuz et al. (2020) discovered that gamification techniques used in language teaching improved learners' writing process in terms of enjoyment and quality. It was also suggested that gamified techniques can be useful for both teachers and learners thanks to the online opportunities of practical feedback, grading, personal space, and improved performance.

As can be seen in related studies, many techniques and approaches have been employed to develop the language skills of EFL learners all over the world. Whereas many of these practices yield very promising results for future research to build upon, it is possible to trace problems related to the implementation of the techniques and methods, learners' responses, interest of learners, technical problems, apprehension, and so on. The main message of the related literature is to carry on trying different techniques and collect as much information as possible in different contexts. Therefore, all these studies are quite valuable to this study because they point to possible problems that may be encountered on the way of implementing technological tools and online platforms to develop language skills or they can underline what to be careful about during the practice of similar techniques in this study.

In this sense, the study aims to answer two main research questions related to the effect of gamification on EFL learners' language skills:

1. What is the impact of gamification on high school EFL learners' language skills?

2. What are the opinions of high school EFL learners about gamification as a language learning technique?

Method

Research Design

In the research, a mixed-method research technique in sequential explanatory design was employed as suggested by Creswell (2007) and Miles et al. (2014). According to this design, it is assumed that supporting the statistical findings with the qualitative data would lead to a more comprehensive understanding of students' language skill development.

The study utilized an experimental design without a control group due to restrictions from the school board requesting that classroom groups and a level-based system be maintained. The administrators of the high school dictated that every student must receive the same type of instruction in intact groups.

As for the qualitative data, the content analysis technique was employed. In the content analysis, the data are analyzed to detect recurring statements and they are categorized under themes and codes (Creswell, 2007; Miles et al., 2014).

Participants

The study involved 72 high school students from a private high school in Turkey who were attending the 9th and 10th grades during the 2020-2021 academic year. For writing skills, 47 of these students were involved in measurement because only these students successfully submitted both their pre-test and post-test written assignments. The rest either had a completed assignment in the pre-test phase or the post-test. The convenience sampling method was used to select the study's participants. Table 1 demonstrates the participants' demographic characteristics in the sample.

Table 1 Participants' demographic characteristics

Skills	**Gender**		
	Female	**Male**	**Total**
Grammar, Vocabulary, and Reading	43	29	72
Writing	24	23	47

Data collection

For the collection of the data, two proficiency tests provided by the WEXT company which prepared Oxford-supported test content and used Common European Framework of Reference (CEFR) based grading were administered to the students to determine their language skill competence. This test package was bought by the school administration in collaboration at the beginning of the semester to ensure reliable and valid testing. These tests included sixty questions in total and included grammar, vocabulary, reading, and listening sections each of which included 15 questions. Based on their answers in each section, students were assigned to level-based groups as follows: A1, A2, B1, and B2. This meant that their scores in the proficiency tests were of ordinal data because they were ranked based on proficiency.

The WEXT proficiency test is an artificial intelligence (AI) powered system that provides individuals with personalized content based on their performance. This way, one can learn their proficiency level by testing their knowledge in various questions in skill areas. For writing skill competence, students' written assignments before the intervention and their final module assignments were collected and graded based on a rubric (Table 2), and the scores were compared.

Table 2 Paragraph Development Rubric

Criteria	Points Possible	Points Given
Topic sentence use	20	
Grammar	20	
Mechanics	20	
Development/Cohesion	20	
Vocabulary	20	
Total	100	

For the qualitative data, one semi-structured interview question was asked to learners after the gamified experience. They were asked about how they found the Canvas modules and the gamified experience related to language learning. The question was prepared with the consultation of two professors in the English Language Teaching (ELT) department. The posing of the question was decided to be a general statement because it would be more appropriate not to suggest anything related to language skills to learners. This way, their feelings related to their experiences would be unbiased and any relation to language skills could be their natural responses.

Procedure

As the first step, after several meetings with administrators and teachers, the schedule of procedures was agreed upon. The teachers were given training about gamification and blended learning models so that they could give informed contributions during planning and direct their classes appropriately. Then, the modules were created through collaboration with teachers, holding weekly meetings to convert the national curriculum into a gamified and blended experience and matching the created content to learning outcomes. Students' opinions about their expectations were asked and a prize store where they can spend their earned points and buy prizes was created. Subsequently, seven modules (Figure 1) were designed on Canvas learning management system (LMS). All modules were enriched with game elements such as points, badges, progress checks, immediate feedback, aesthetics, online interaction, prizes, and rewards.

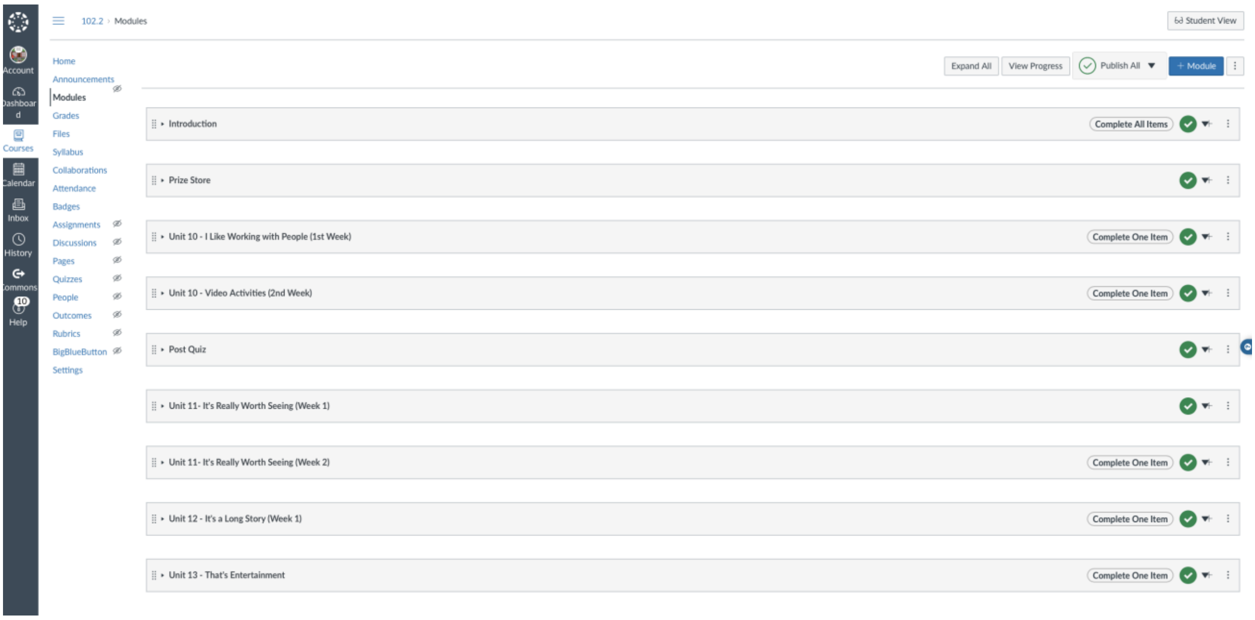

Figure 1 Sample structure of modules

The students were informed about the gamified process and asked to complete the modules. The modules involved reading, grammar, vocabulary, and writing activities as a complement to their face-to-face main course lessons. Once the preparations were complete, teachers ran their classes regularly in face-to-face sessions, covering the main course sessions in the book. After the completion of each module, students earned points which they could redeem for gifts at any point during the semester in the prize store. Each module typically started with a revision of face-to-face sessions, then introduced a revision quiz about the weekly topics. Then, students were asked to participate in online discussions related to the issues, read passages, and answer reading comprehension questions. Next, students were presented with videos related to the book unit and discussed the questions about those videos in online discussion sections. In some modules, learners were given collaborative tasks such as writing scripts for their friends to shoot videos. Finally, the modules were concluded with a written assignment (Figure 2), asking students to follow instructions and develop paragraphs accordingly. For each module assignment, certain grammatical structures, paragraph development techniques, and pragmatic units were set as criteria.

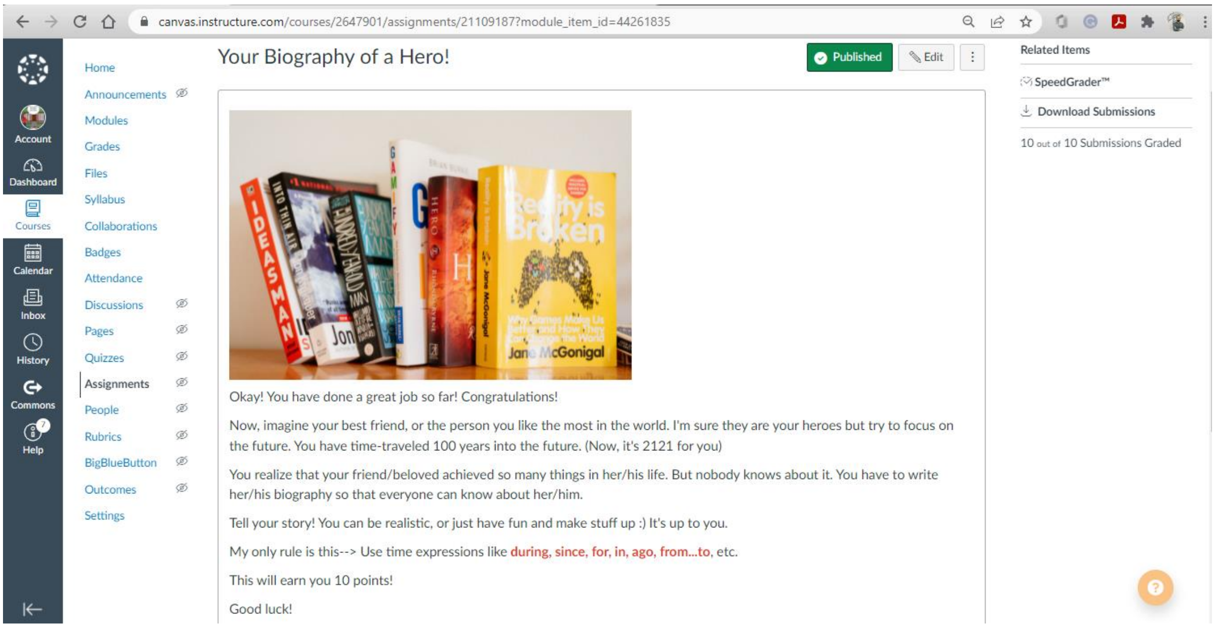

Figure 2 Sample Weekly Written Assignment

After the implementation of modules in a blended and gamified instructional process, learners were presented with an online interview form inquiring about their experiences with the modules. Students were asked to answer the question, "What can you tell us about your language learning experience with the Canvas modules?". Their responses were used to inform the quantitative findings of the study regarding language skills.

Data Analysis

Following the separate analyses of pre-test and post-test language competence levels of participants, comparisons were made between pre-test and post-test scores of EFL learners by utilizing the Wilcoxon Signed Rank test because the skill scores consisted of ordinal data. To make a comparison between students' writing skills before and after the module, previous written assignments of these 47 students which were written on certain topics were found by their teachers. After obtaining the assignments, one teacher was asked to collaborate with the researcher in scoring the assignments again based on the rubric for paragraph development.

In learners' language skill competence calculations, Wilcoxon Signed Ranks test as a non-parametric test was used since the learner data related to the language competence were of ordinal data type. For this reason, in the presentation and tabulation of the data, the statistical information about medians (Mdn) and the Z values was accounted for.

For the qualitative data regarding students' opinions about the module, a content analysis technique was used to identify certain themes and codes. Dedoose qualitative data analysis software was used to analyze qualitative data.

Validity and reliability

The reliability score for the six-item rubric used in measuring (topic sentence use, grammar, mechanics, development/cohesion, vocabulary, and total score) was calculated with the formula proposed by Miles and Huberman (1994). The reliability score was found to be .75 (6/8). These values indicated that the rubric can be used to measure the writing skills of the students reliably. The scorers marked the assignments independently first, then the scores were compared in several meetings to see if there were big differences to ensure inter-rater reliability. All scores were compared one by one and the scorers compromised if necessary.

For qualitative data analysis's reliability, in addition to the researcher, an area expert independently coded the responses given by the participants. The clusters were compared, and the agreed clusters were given theme and code names. In terms of intercoder reliability, in accordance with the formula developed by Miles et al. (2014), the reliability score was calculated as .87 (105/122=0.87). This indicated that the coding process indicated a reliability between two coders.

Findings and Discussions

Considering the total language competence scores of participants, it was found that their language competence after the intervention (*Mdn* = 61.1) was significantly higher than their pre-test competence level (*Mdn* = 44.4), indicating a statistically significant improvement, $Z = -4.54$, $p = .000$, $r = .37$ (Table 2).

Table 2 Comparison of participants' general language competence score

Test	Ranks	N	Mean Rank	Z	p
Pre-test and post-test comparison	Negative Ranks	15	33,63	-4.54	.00
	Positive Ranks	57	37,25		
	Ties	0			
	Total	72			

Note. N=72

Regarding grammar, vocabulary, and reading skills, it was revealed by the tests that grammar and reading skills yielded statistically significant improvements while vocabulary skills did not show any statistical significance in the competence score difference (Table 3).

Table 3 Comparison of grammar and reading competence

Test	Ranks	N	Mean Rank	Z	p
Grammar competence	Negative Ranks	7	13,86	-5.11	.00
	Positive Ranks	41	26,32		
	Ties	24			
	Total	72			
Reading competence	Negative Ranks	12	44,38	-3.80	.00
	Positive Ranks	55	31,74		
	Ties	5			
	Total	72			

Note. N=72

According to the table, participants received lower grammar scores in the test (*Mdn* = 50) before the intervention compared to their scores after the module (*Mdn* = 50), showing a statistically significant improvement, $Z = -5.11$, $p = .000$, $r = .42$. Similarly in their reading competence, EFL learners were significantly more successful after the implementation of the module (*Mdn* = 83.3) in comparison to their pre-test performance (*Mdn* = 50), $Z = -3.80$, $p = .000$, $r = .31$.

The writing competence of the participants was analyzed through a series of Wilcoxon Signed Ranks tests to see the differences in competence. In a general sense, the participants' writing competence did not show a statistically significant increase. However, their pre-test scores (*Mdn* = 72.5) showed an increase in the post-test (*Mdn* = 75). Therefore, it is possible to state that their writing competence improved despite not being statistically significant.

Regarding the opinions of learners about the module, responses to the open-ended question were analyzed and certain codes and bigger themes were generated based on the statements as shown in Figure 3.

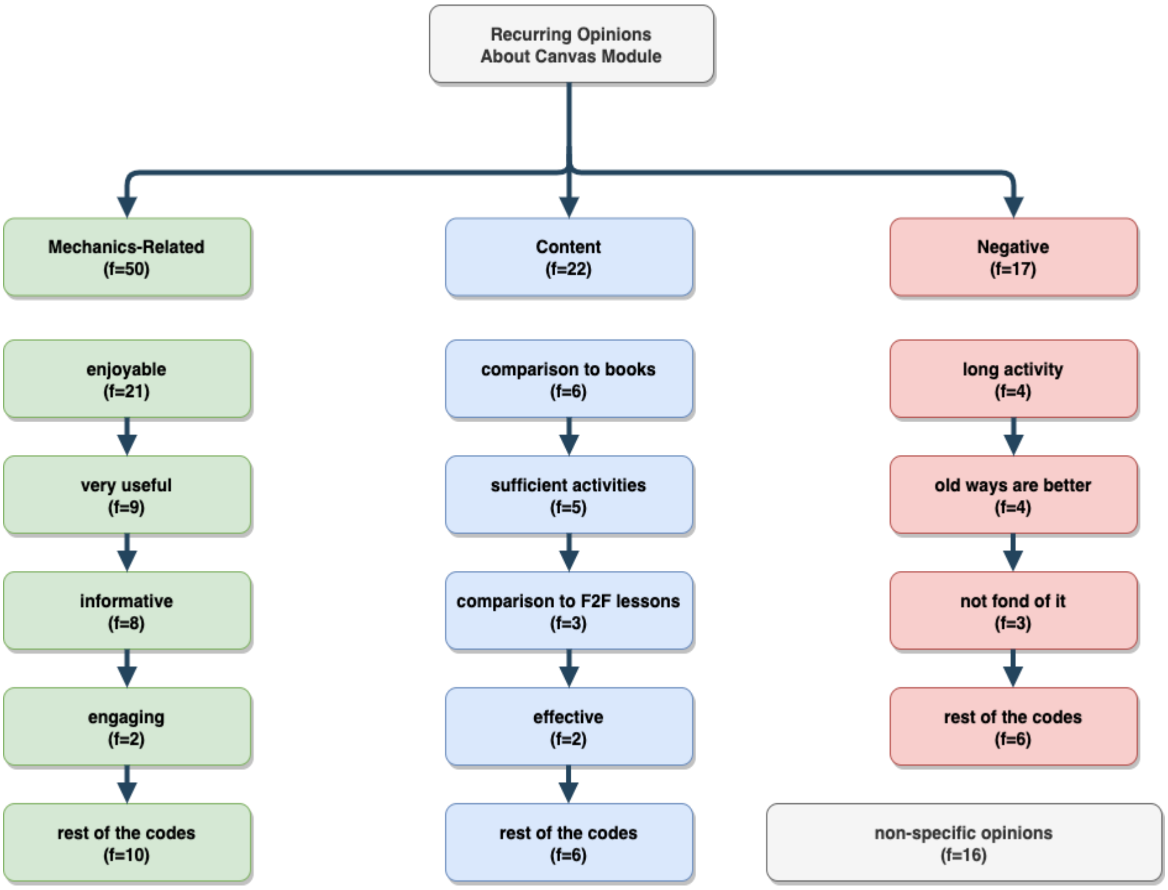

Figure 3 Opinions of learners

Under the theme of mechanics-related opinions, for instance, enjoyable (f=21) code was the most frequently recurring response from the learners. Many responders used the word *enjoy* in their opinions either as a standalone mood or as an accompanying feeling with other opinions. For instance, P17 said, "*It's a nice and fun website. I enjoy and learn.*", and similarly, P42 stated, "*I think Canvas module and activities are very nice. I really liked it. It's a positive platform for learning and enjoying. I learn by having fun.*". In addition to enjoyable code, in nine instances, participants mentioned the usefulness of the module. According to P66, the module was "*…a useful system with a very high function.*", indicating that a considerable number of students found the module useful. Apart from finding it enjoyable and useful, participants also added the informative side of the module to their responses. In eight comments, students mentioned that the module was an educational experience for them aside from being fun and useful. For this, P27 remarked, "*I think it was useful. We have fun and we can improve our English*".

For the remaining themes, learners compared the modules to coursebooks and normal lessons and found the modules sufficient and effective. However, 17 participants indicated negative comments, finding the experience long or difficult. Some of them wanted to go back to their previous lesson style. Under the non-specific opinions, students mentioned unrelated things such as failing to find enough time for modules, so they did not experience everything to the fullest.

In the research, language skills of learners such as reading, grammar, vocabulary, and writing went through an affirmative change after the implementation of the modules. The use of a blended design and a gamified platform provided promising and potent results for the future of gamified language learning environments.

Recalling the findings related to language skills, it was found that the module increased the participants' grammar and reading skills at a statistically significant level, and their general language competence seemed to have increased significantly, as well. However, in terms of vocabulary and writing competence, even though students' scores showed an increase, it was not statistically significant. These increases experienced in students' measured language skills showed that gamified and blended learning settings can positively affect the language skills of EFL learners.

As the first focal point, it was seen that learners advanced in their grammar and reading skills at statistically significant levels. However, vocabulary skills did not indicate an improvement at the same rate as grammar and reading skills. Based on the qualitative responses of learners, it can be stated that learners preferred these modules for a variety of reasons such as teacher support, easy and organized access to the materials, alternative ways of communication, and opportunities unique to technological and digital platforms.

Going back to the related literature, Krashen (1989) pointed out that vocabulary acquisition and development are dependent upon the frequency and quality of reading. This outcome in vocabulary might be an indication that learners need to make reading a strict habit and they probably needed more time practicing reading. In addition, as Sze (1999) stated, interest in reading is always at risk of dropping over time, and it must be rekindled constantly through extensive reading activities. Therefore, it can be inferred that these learners must be exposed to more frequent reading and their teachers must provide their students with creative extensive reading opportunities. Just as Robert and Neal (2004) found, this study can conclude that teachers must be more present in supporting learners extensively to improve reading and vocabulary because it was found that making the learning blended and allocating activity time outside the classroom helped learners' reading, grammar, and vocabulary skills.

Additionally, it can be inferred from the findings that collaborative and communicative activities such as group projects, pretend interviews, online discussions, and role-playing activities were found useful in developing grammar, reading, and vocabulary skills by learners, which coincides with the findings of Sidek (2012). In connection, Sidek (2012) and Konstantakis and Alexiou (2012) complained that course books of the time were not comprehensive in covering all necessary vocabulary and communicative functions; therefore, they advocated using multiple textbooks or a variety of materials to improve vocabulary. In this direction, this study achieved good results because the number of materials and types of activities used in the modules were quite high, which was mentioned and commended by learners themselves in their qualitative responses.

In the sense of writing skills, learners emphasized the benefits of online platforms and technology use because these modules offered them alternative means to say what they wanted to say. According to one student, they were able to speak their minds in written statements even if they might normally feel shy in spoken communication. In addition, they underlined that writing activities helped them improve their skills. Another aspect that was mentioned by learners in the study was the opportunity to work independently (La Isla, 2018). This gave them time to think about their answers, making revisions before submitting when necessary. These results aligned with the findings and recommendations of several related researches (Apel & Worfer, 2014; Aydın & Başöz, 2010; Espinoza-Celi & Pintado, 2019; Kayacan & Razı, 2017; Savran Çelik & Aydın, 2016; Valizadeh, 2022). For instance, Aydın and Başöz (2010) found that giving students opportunities to make revisions and rewriting improved learners' opinions of writing.

As for the benefits of the module in improving students' writing skills, Apel and Worfel (2014) suggested teaching the mechanics of the language such as morphology, which reflected the nature of the modules used in this context. The modules included almost everything related to language structures and provided guidance for some writing mechanics such as developing paragraphs, writing summaries, and producing essays. Therefore, it can be inferred that just as Apel and Worfel (2014) found, introducing structural and mechanical knowledge to students can help them to improve their writing.

Furthermore, since the modules adopted process-based writing in principle and succeeded to some extent, this can be aligned with the findings of Savran Çelik and Aydın (2016) who revealed that process-based writing can lead to improvement in writing skills. In addition, as revealed by Kayacan and Razı (2017), Espinoza-Celi and Pintado (2019), and Valizadeh (2022), the integration of technology and the use of technological tools genuinely increased the odds of improving writing skills because learners enjoyed the opportunities offered by online platforms and use of LMS platforms.

Concerning gamification, the findings of the study showed similarities to the related research in several ways. Initially, Flores (2015) and Pham et al. (2021) found that gamified language learning could increase learners' language skills and achievement, coinciding with the findings of this study. In the current study, learners' language competence showed an increase due to gamified and blended modules.

Additionally, the study found that the grammar skills of learners showed a statistically significant increase, and learners regarded the modules as informative, better than coursebooks and face-to-face activities, and effective. This outcome was relevant to the related research by Purgina (2020) who discovered that gamification could help increase grammar skills. On the other hand, even though no statistically significant improvement was detected, the study indicated an elevation in the writing skill. This showed parallels with the results of Samosa et al. (2021) and Yavuz et al. (2020), revealing that gamified lessons could enhance writing achievement and quality in language learning.

As indicated by Hernández-Prados et al. (2021), this study also found that EFL learners favored the learning experience where game elements enriched the process. Moreover, learners in the study mentioned engagement as one of the factors for their success, similar to the results of the study by Selvasli (2018) in which gamification increased learners' homework engagement and language achievement.

In short, it can be remarked that using technological tools, gamifying the process, providing students with constant support, and giving them opportunities to work independently and make revisions of their writing helped learners feel comfortable and motivated to work on their progress. A gamified and blended approach to language learning served greatly to EFL learners as a good mixture of language learning innovation. It can be inferred from this study that balancing out the incompatible parts of disruptive technologies and innovative techniques with close consideration for learners' needs can greatly improve the quality of language learning (Azzouz & Gutierrez-Colon Plana, 2020; Samosa et al., 2021; Yavuz et al., 2020).

Conclusions and Suggestions

As can be seen in the findings and discussions section, learners' language skills showed promising improvements. Based on the views of students, providing alternative ways to communicate, offering a diverse range of activities, enabling students to practice language skills through extensive work, and providing constant and non-delayed feedback all function well with blended and gamified language learning environments. It can be concluded that the diversifying effect of blended learning and the engagement-invoking nature of gamification can work well in harmony to improve their language skills. Creating such blends that will ensure elevation in learner engagement, motivation, and language competence is possible through arduous instructional design processes during which researchers, teachers, students, and other possible stakeholders work in collaboration. Negotiations over the course contents and language learning procedures are crucial to reach the objectives of the lesson without discouraging stakeholders.

In light of the study's results, several suggestions can be made. First, true experimental research designs can serve better to understand the effect of blended and gamified instruction as this study employing a design without a control group was limited in this regard. Rather than comparing previous situations to the aftermaths of the intervention, making comparisons with a control group can work better. Second, studies with a large attendance of learners should be conducted to reach results with more generalizability. Third, teachers must be given more training sessions about gamification and blending of the learning because inaccurate or inappropriate actions during the instruction can damage the integrity of the study. Last, similar studies must be conducted in different contexts and with other variables.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The authors declare that this study and no processes involved in conducting the study have the potential for conflicts of interest.

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CRediT author statement

Author 1: Conceptualization, Data curation, Formal Analysis, Funding Acquisition, Investigation, Methodology, Resources, Software, Visualization, Writing - original draft, review, and editing

Author 2: Conceptualization, Methodology, Writing – review, editing

Research involving Human Participants and/or Animals

The research was investigated by the Ethics Committee of Çanakkale Onsekiz Mart University School of Graduate Studies and approved with the reference number "08/20" dated 29.04.2021.

Oyunlaştırılmış ve Harmanlanmış Modüllerin İngilizceyi Yabancı Dil Olarak Öğrenenlerin Dil Becerilerine Etkisi

Özet:

Oyunlaştırma, İngilizce öğretimi bağlamında en popüler konular arasında yer almaktadır. Oyunlaştırılmış dil öğreniminin etkisi üzerine çok sayıda çalışma olmasına rağmen, farklı bağlamlardaki dinamiklerini anlamak için daha fazla araştırma yapılması gerekmektedir. Bu nedenle, bu çalışma lise öğrencilerinin yedi haftalık oyunlaştırılmış ve harmanlanmış dil öğrenme deneyiminden sonra belirli dil becerilerini keşfetmeyi amaçlamıştır. Oyunlaştırılmış içeriğin öğrencilerin okuma, kelime bilgisi, dil bilgisi ve yazma becerileri üzerindeki etkisini anlamak için karma yöntemli bir araştırma tasarımı kullanılmıştır. Öğrencilerin okuma, kelime bilgisi ve dil bilgisi becerileri, öğretim öncesinde ve sonrasında uygulanan yeterlilik testleriyle ölçülürken, yazma yeterlilikleri öğrencilerin yazılı ödevlerinin notlandırılmasıyla ölçülmüştür. Ayrıca, istatistiksel bulguları nitel verilerle ilişkilendirmek için öğrencilerin deneyime ilişkin görüşleri de toplanmıştır. Sonuç olarak, oyunlaştırılmış öğrenme deneyiminin öğrencilerin dil becerilerini geliştirdiği ve öğrenen görüşlerinin bu sonuçları yeterince açıkladığı bulunmuştur.

Anahtar kelimeler: dil becerileri, harmanlanmış öğrenme, oyunlaştırma, yabancı bir dil olarak İngilizce.

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Research Article

Evaluation of Writing Skills Learning Field according to Stake's Responsive Evaluation Model in terms of Gifted and Talented Students*

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Abstract – This research aims to evaluate the 2019 Turkish curriculum writing skills learning field in terms of gifted and talented students. In the research, a holistic single case design, one of the case study designs, was used. The study group was determined by using “criterion sampling” and “convenience sampling” methods from the purposive sampling methods. The sample of the research consisted of gifted and talented students at the fourth grade level in the Sincan region of Ankara province. Within the scope of the research, 21 volunteer students were interviewed. A semi-structured interview form developed by the researcher was used as the data collection tool. The data were collected in April and May 2022. The content analysis method was used to analyze the data. The reliability of the study was determined to be 0.83. The results indicate that the students experience writing anxiety, the topics are relatively appropriate to the level of the students, the variety of methods and techniques and the time are insufficient, and both traditional and alternative assessment methods are used during the evaluation.

Key words: Turkish curriculum, writing skills, Stake's responsive evaluation model, gifted and talented student.

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Introduction

Individuals have different developmental characteristics in terms of mental, physical, social, and affective aspects. While some individuals have developmental disorders in their mental, motor and affective skills compared to their peers, some individuals can show high level performances. To improve the behaviors and skills of these individuals and facilitate their adaptation to their environment, educational services need to be adapted. This need has led to the concept of "special education" (Subakan & Koç, 2019). Special education is a set of individually planned, implemented, and evaluated teaching services to increase the possibility of independent living for individuals with special needs. Individuals with special needs include mental deficiency, learning difficulties, emotional and behavioral disorders, severe and multiple disabilities, hearing deficiencies, communication disorders, visual deficiencies, physical and health related deficiencies, and gifted and talented students (Eripek, 2005).

Among the individuals with special needs, gifted and talented individuals are individuals who can exceed the IQ threshold score of 130 in intelligence tests according to the conservative approach. In liberal definitions, gifted and talented individuals show a high level of capacity or high potential in any field of performance (Sak, 2012). Gifted and talented individuals demonstrate different learning behaviors from their peers in terms of cognitive, affective, and communicative aspects. The curriculums prepared to reveal and develop the individual potential of gifted and talented students should be prepared by considering their needs, individual differences, interests, and learning profiles. For this reason, differentiation is made in existing curriculums (Öznacar & Bildiren, 2016; Tortop, 2015).

Differentiation is the design of learning activities by adapting the existing curriculum objectives to gifted and talented students. In the process of differentiation, some parts of the existing curriculum can be removed and education can be accelerated or new learning objectives can be added to the curriculum and education can be enriched (Sak, 2012). Differentiation is done in the content, process, product, and environment elements of the curriculum. The content element is the information to be taught. It is the facts, concepts, principles and skills in a lesson, learning experience or unit (Tomlinson, 2007). Content-based enrichment is the further expansion and deepening of content beyond the existing curriculum. Enrichment can be done in lessons such as mathematics, science, social studies, and grammar (Sak, 2012). The process element is the activities designed to teach knowledge and skills. In the process element, it is necessary to include activities that are appropriate to the student's level of readiness, meet a goal, attract attention, and associate new concepts and skills with prior knowledge (Tomlinson, 2007). The process element includes appropriate strategies, methods, techniques, and research skills, allowing students to use their thoughts and knowledge (Şahin, 2018). Process-based enrichment develops students' creativity, critical thinking, and problem-solving skills (Sak, 2012). The product element is the means by which students exhibit what they have learned. Products should be diverse in terms of students' readiness, interests, and learning profiles, be appropriate to the content and process elements, help students express themselves, and allow them to reveal success in a qualified way (Tomlinson, 2007). The product element for gifted and talented students should be differentiated according to criteria such as innovation, depth, originality and relevance to life (Şahin, 2018). Product-based enrichment focuses on tangible products such as novels, poems, stories, reports, and projects as well as abstract products (Sak, 2012). In differentiation related to the environment element, different places such as museums, exhibitions, laboratories, and libraries should be differentiated in terms of time and materials in addition to classical classrooms (Şahin, 2018).

In 1982, the National/State Leadership Training Institute presented the following differentiation principles for gifted and talented curriculum (Kaplan, 1986).

- Content that covers a wide range of topics, themes and problems should be included.
- In-depth learning of the selected topic in the field of study should be provided.
- More than one discipline should be integrated into the field of study.
- Comprehensive, interrelated and mutually reinforcing experiences should be included in a field of study.
- Focus on developing basic skills, independent learning, abstract and higher order thinking skills, research skills and methods.
- Open-ended tasks should be included.
- Individuals' awareness should be developed, such as recognizing their abilities, self-management, distinguishing similarities and differences between themselves and others.
- Encourage the development of products that use techniques, materials and forms that allow changing existing ideas and generating innovative ideas.
- Student outcomes should be assessed through self-assessment, criterion-based and standardized tools using appropriate and specific criteria.

Curriculum differentiation for gifted and talented students requires more thought and work than simply combining a few activities. Curriculum differentiation should focus on thinking skills, abstract concepts, advanced content, interdisciplinary studies, and curriculum experiences that integrate content, process, and product (Renzulli, 1988). Therefore, integrating enrichment in content, process and product elements leads to more qualified results (Sak, 2012). It can be said that it is important to make differentiation and enrichment in the curriculum of gifted and talented students to increase the efficiency of their education. One of the lessons that require differentiation and enrichment is the Turkish curriculum.

The Turkish lesson basically includes four skills, namely listening and speaking skills acquired naturally and reading and writing skills acquired through instruction. Natural skills are acquired and developed more easily due to human nature. On the other hand, reading and writing skills based on writing are more difficult to acquire and take time to develop. Writing is a complex and difficult skill that requires effort. Writing skill, which is a learning field for Turkish lesson, is a skill that has a regulatory effect on mental processes as well as being a language skill (Çevik, 2021). Writing enables thoughts to be organized through mental processes, transferred into sentences and communicated. Through writing, thoughts are questioned, revised and reinterpreted. Writing skills develop students' mental, language and social skills. To develop writing skills, mental preparation is a prerequisite (Güneş, 2021).

Practices for developing writing skills are carried out within the framework of writing approaches. Two approaches, product-oriented and process-oriented, are generally prominent in writing education and practices (Kaldırım & Tavşanlı, 2021; Tabak & Göçer, 2013). The product-oriented writing approach focuses on the written expression product rather than the process in written expression studies (Kaldırım & Tavşanlı, 2021). This approach adopts a teacher-centered approach, ignores individual differences in the writing process, and attaches importance to formal elements in writing (Tabak & Göçer, 2013). On the other hand, the process-oriented writing approach requires students to have cognitive awareness in the writing process, to focus on the thinking process, and to organize each stage of the writing process. It provides students with independent thinking, problem solving, decision making and learning to learn skills (Karatay, 2013). In the process-oriented writing approach, the focus is on the process until the product emerges. In this approach, students are allowed to present and organize their thinking, decision-making, and feelings and thoughts about the stages of writing in fluently and logically (Karadağ-Yılmaz & Erdoğan, 2020). Therefore, the aim of the process-based writing approach is to eliminate writing barriers. The process-oriented writing approach consists of preparation, drafting, revising, editing, and publishing/sharing stages (Tabak & Göçer, 2013). Teachers' adoption of a common writing approach at every stage of the writing process enables them to regularly monitor their written expression activities and make efficient evaluations. Through evaluations, students' deficiencies can be identified and correct guidance can be given to correct these deficiencies (Karatay, 2013).

With evaluation, it becomes possible to assess the aspects of the curriculum, collect information on issues related to the efficiency of the curriculum, draw conclusions from the data obtained, make decisions, and implement the decisions taken. Therefore, curriculum evaluation can be considered as the process of making decisions about the effectiveness, efficiency, consistency, adequacy, applicability, and executability of curriculum by using the stages of the scientific research process (Uşun, 2016). If there is a deficiency in the curriculum as a result of the implementation, evaluation is carried out to determine elements causing problems and to make corrections (Demirel, 2015). Curriculum evaluation can be designed and carried out according to which approach the curriculum to be evaluated is based on, what its main principles are, and what kind of individuals it wants to raise (Özdemir, 2009).

In the related literature, there are various classifications regarding curriculum evaluation models. For example, Fitzpatrick et al. (2019) categorize evaluation approaches into five groups: Objectives-oriented, management-oriented, expertise-oriented, consumer-oriented and participant-oriented. In addition to this classification, Aygören and Er (2018) also included an adversary-oriented approach and examined evaluation designs under six different models.

The “responsive evaluation” model, which is one of the participant-oriented evaluation models, was developed by Robert Stake in 1973. It can be said that this model is less formal, more pluralistic, and processes-focused than the models developed by Stake himself. This evaluation model differs from other models in that it has flexible, variable methods and approaches; it values pluralism; it is important to convey specific knowledge, theory, and details about the topic; case studies and qualitative methods used to understand the details of an event are important; the evaluation is comprehensive and reflects the whole complexity of the curriculum; evaluation reports are presented in a rich information network; the task of the evaluator is to mediate the person's ability to reach their own outcomes (Fitzpatrick et al., 2019). In Stake's responsive evaluation model, the effectiveness of the curriculum and the evaluation of the process are more important than the outputs. The evaluator should tell the story of the curriculum, state what the characteristics of the curriculum are, describe who the participants are and what characteristics they have, highlight important issues and problems in the curriculum, and report achievements (Demirel, 2015; Sönmez & Alacapınar, 2015).

Stake's responsive evaluation model has 12 steps: "Talk with clients, program staff, and audiences; identify program scope; overview program activities; discover purposes and concerns; conceptualize issues and problems; identify data needs and issues; select observers, judges, and instruments, if any; observe designated antecedents, transactions and outcomes; thematize, prepare portrayals and case studies; validate, confirm, and attempt to disconfirm; winnow, format for audience use; assemble formal reports, if any" (Stake, 2011). These steps are described in the form of a clock, which indicates sensitivity and flexibility. Although the evaluator starts the evaluation at 12 and continues clockwise, Stake emphasized that any step can follow another step and the evaluator can move counterclockwise or diagonally at any point if the situation requires a change. In addition, many steps can be performed simultaneously and some of the steps can be performed more than once (Fitzpatrick et al., 2019). In the research, the reason why Stake's responsive evaluation model is preferred is that it considers the needs of the participants, it has a pluralistic and flexible perspective, case studies and qualitative methods are important, the evaluation is holistic, important issues and problems in the curriculum are highlighted, the effectiveness of the curriculum and the process are evaluated, and the evaluation report is comprehensive.

As can be understood from what has been written, the Turkish curriculum writing skills learning field is prepared for students studying in general education classes. However, there is a need for a differentiated Turkish curriculum writing skills for gifted and talented students. In the process of differentiating Turkish curriculum writing skills according to the learning characteristics and needs of gifted and talented students, it is not known how the curriculum elements will be differentiated. At this point, it is important to evaluate the Turkish curriculum writing skills learning field by taking the opinions of gifted and talented students. In this context, the aim of the research is to evaluate the 2019 Turkish curriculum writing skills learning field in terms of gifted and talented students. Within the scope of this purpose, an answer to the question "What are the opinions of gifted and talented students on the objectives, content, learning experiences, evaluation, positive and negative aspects and suggestions of the 2019 Turkish curriculum fourth grade writing skills learning field?" is sought.

Method

Research Design

In this study, which evaluated the 2019 Turkish curriculum fourth grade writing skills learning field, a case study, one of the qualitative research methods, was used. Case studies are used to examine situations such as individual, group, organizational, social, and political issues that contribute to our knowledge. In other words, this method allows us to understand holistically the characteristics of real life events such as individual life cycles, small group behavior, neighborhood change, school performance, organizational and managerial processes, international relations, and the development of industries. The case study enables in-depth examination of a phenomenon or event based on how and why questions (Yin, 2009). In the research, “a holistic single case design”, one of the case study designs, was used. In single case designs, there is an individual, an institution, a curriculum or a school (Yıldırım & Şimşek, 2013). In this study, the 2019 Turkish curriculum fourth grade writing skills learning field was determined as a case and evaluated.

Participants

In studies based on qualitative research methods, purposive sampling methods that allow in-depth investigation of situations that are thought to have rich information are preferred. In this research, the study group was determined by using “criterion sampling” and “convenience sampling”, among the purposive sampling methods. In convenience sampling, the researcher selects a situation that is close and easy to access. This method provides speed and practicality to the researcher. In criterion sampling, the group that meets the criteria determined by the researcher is studied (Yıldırım & Şimşek, 2013). The sample of the research consisted of gifted and talented students fourth grade level in the Sincan region of Ankara province. The reason for this was that fourth grade students were thought to have a certain maturity in terms of writing skills at primary school level. Within the scope of the research, interviews were conducted with 21 volunteer students. While the number of female students participating in the research was 14, the number of male students was 7. All of the students were studying at a public school.

Data collection

A semi-structured interview form was developed by the researcher to be used in the evaluation phase of the 2019 Turkish curriculum writing skills learning field. To prepare the interview questions, the relevant literature was first reviewed. The prepared interview questions were presented to three experts in the field of curriculum and instruction and one expert in the field of Turkish education. As a result of the evaluations of the experts, the final version of the interview forms was decided. The finalized interview questions were piloted with three students. It was determined that there were no questions that were not understood during the pilot application and the final version of the form was decided. The interview form included detailed questions about the evaluation of the curriculum's objectives, content, learning experiences and evaluation elements. The students were asked questions to determine the skills, feelings and thoughts gained by the students during the writing activities within the scope of the objective element; the topics learned, the level of attractiveness and difficulty of these topics, and their relationship with daily life within the scope of the content element; time allocated to writing activities, materials, methods and techniques used in the activities and communication process during activities within the scope of the learning experiences element; and the assessment methods and criteria of writing activities within the scope of the evaluation element. In addition, the students were asked questions to determine the aspects of the writing activities that were liked and found lacking and to determine the suggestions for the elements of the curriculum.

The data were obtained as a result of interviews with 21 volunteer students in April and May 2022. The interviews lasted approximately between 35 and 55 minutes and the data were collected by voice recording. The data within the scope of the research was collected and analyzed by applying the steps of Stake's responsive evaluation model. The procedures are presented below.

1) Talk with clients, program staff, and audiences: Interviews were conducted with the students to get information about the functioning of the curriculum. The general opinions of the students about the elements of the curriculum, the problems they experienced, their concerns and suggestions for the curriculum to be better were determined.
2) Identify program scope: When the related literature was examined, it was determined that no curriculum development study was conducted by evaluating the 2019 Turkish curriculum fourth grade writing skills learning field in terms of gifted and talented students and taking into account the results. Based on this deficiency, the scope of the curriculum evaluation study was determined.
3) Overview program activities: With the document analysis technique, the 2019 Turkish curriculum was examined in terms of objectives, content, learning experiences, and

measurement-assessment approach. An interview form was developed to determine the effectiveness of these elements.

4) Discover purposes and concerns: The opinions, concerns and problems related to the curriculum obtained as a result of the interviews with the students are given in the findings section of the research.
5) Conceptualize issues and problems: To conceptualize the issues and problems obtained regarding the curriculum, the data were analyzed by the content analysis method.
6) Identify data needs and issues: Within the scope of the evaluation model, the needs regarding the elements of the curriculum, the strengths and weaknesses of the curriculum and the suggestions for the curriculum were determined in detail.
7) Select observers, judges and instruments, if any: A semi-structured interview form was developed to collect data within the scope of the research. The form was finalized after the feedback of three experts in the field of curriculum and instruction and one expert in the field of Turkish education.
8) Observe designated antecedents, transactions and outcomes: The findings and results obtained were compared with the results of the research conducted in the past within the scope of the Turkish curriculum writing skills learning field. The data obtained in this research was supported by the results of previous research.
9) Thematize, prepare portrayals and case studies: The data obtained as a result of the interviews with the students were turned into codes, categories, and themes and presented in the findings section.
10) Validate, confirm, and attempt to disconfirm: To ensure the reliability of the data obtained, both the researcher and a different curriculum development expert coded the data. Reliability analysis was conducted to determine the consistency between the coders. In addition, the data were described in detail in order to transfer the research results to similar environments.
11) Winnow, format for audience use: The findings and results obtained as a result of the research were delivered to the students participating in the study and the data were confirmed.
12) Assemble formal reports, if any: The evaluation study was turned into a report to be presented to the readers and the related literature.

Data Analysis

In this study, content analysis was used to analyze the data. Content analysis aims to identify concepts and relationships that can explain the collected data. For this purpose, concepts are first obtained from the collected data, then the concepts obtained are organized, and themes explaining the data are obtained (Yıldırım & Şimşek, 2013). The students' views on the 2019 Turkish curriculum writing skills were analyzed from a holistic perspective in terms of the elements of the curriculum, namely the objective, content, learning experiences and evaluation, the positive aspects, negative aspects and suggestions regarding the curriculum. As a result of the analyzes, codes, categories, and themes were obtained.

Validity and reliability

To increase the internal validity of the study, the researcher summarized the data collected immediately at the end of the data collection and asked the participants for their opinions on their accuracy. The data obtained from the interviews were described objectively by including direct quotations. The data were transferred by remaining faithful to their nature. To ensure external validity in the research, the process of developing the data collection tool, data collection, sampling group, data analysis, and interpretation process were explained from an objective point of view. The research report was presented in detail in order to transfer the research findings to other environments.

To ensure the internal reliability of the research, the interview questions were asked to all participants in the same way. The data were coded separately by both the researcher and a different curriculum development expert. An evaluation was made to see whether the findings, conclusions, and suggestions could be confirmed when the raw data were returned. To determine the consistency of opinion between the coders, the reliability formula suggested by Miles and Huberman (1994) as "Percentage of Agreement = Agreement / (Agreement + Disagreement) X 100" was used. As a result of the calculation, it was determined that the reliability of the study was 0.83. To ensure external reliability in the study, the researcher clearly stated her role. The students who participated in the study were coded between S1 and S21 so that their identities would not be revealed. The sampling method used to identify the students was explained in detail. To prevent the loss of the data obtained from the interviews with the students, the data were recorded on a voice recorder. Explanations on how the interviews were conducted were presented in detail. During the data analysis, data diversity was ensured by including the opposing opinions obtained from the students.

Role of the Researcher

The corresponding author of the research is a teacher at a science and art center in the Sincan region of Ankara province for four years. She taught the students constituting the study group of the research for two years. This situation allowed the study group to show more natural behaviors during the data collection process and to give more objective answers to the interview questions. In addition, the corresponding author of the research has been continuing her doctoral education in the field of curriculum and instruction. She has knowledge in the field of curriculum development and evaluation. The second and third authors of the research have been conducting studies both in the field of curriculum development and evaluation and in the field of gifted and talented.

Findings and Discussions

To evaluate the 2019 Turkish curriculum fourth grade writing skills learning field, interviews were conducted with students. Student opinions were analyzed under the headings of “objectives”, “content”, “learning experiences”, “evaluation”, “positive and negative aspects” and “suggestions”. The findings obtained within the scope of the research are presented below.

Students' Opinions Related to the Objective Element of the Curriculum

In the 2019 Turkish curriculum fourth grade writing skills learning field, the “objectives” achieved by students are examined in three themes: “Cognitive aims”, “affective aims” and “psychomotor aims”. In the “cognitive aims” theme, the categories of “mental skills”, “text analysis”, “vocabulary” and “spelling rules” are obtained. In the “affective aims” theme, “positive attitude”, “negative attitude” and “anxiety” categories are obtained. The categories of “writing skills” and “pencil holding skills” are obtained in the theme of “psychomotor aims”. Codes and categories related to the themes are presented in Table 1.

Table 1 Codes, categories and themes related to the objective element of the curriculum

Theme	Category	Code	f
Cognitive aims	Mental skills	Development of imagination	7
		Increased knowledge related to the topics in Turkish lesson	6
		Development of thinking skills	2
		Enduring learning	1
		Research skills	1
	Text analysis	To be able to write text types according to their features	7
		To be able to understand text types	2
		To determine the topic and main idea of the text	2

	Vocabulary	To learn new vocabulary	5
		To be able to make a sentence	4
		To be able to speak fluently	1
	Spelling rules	Using punctuation marks correctly	2
		Using conjunctions correctly	2
Affective aims	Positive attitude	Being happy while writing	12
		Enjoy writing	8
		Feeling good about yourself	4
		Getting excited	3
	Negative attitude	Getting bored while writing	2
		Unwilling to write	2
	Anxiety	Worrying about not being able to understand the writing topic	7
		Fear of not being able to write	3
		Feeling of being disliked	3
		Difficulty in expressing feelings	1
Psychomotor aims	Writing skills	To be able to write beautifully	10
		Development of writing skill	9
		To be able to write fluently	1
	Pencil holding skills	To be able to hold the pen correctly	2
		Developing the skills of drawing a picture	1

Codes are obtained under the category of “mental skills” related to the “cognitive aims” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that while doing writing activities, their imagination develop, their thinking skills improve, their knowledge of the topics in the Turkish lesson increase, permanent learning occur, and their research skills improve. Some of the student views are given below.

S9: “When I study or memorize something, I want to write it first. When I write it, it stays in my mind. When I read something and I write by looking at something, I am dreaming. Let's say I am writing a book, I write short something, it immediately comes to life in my mind.”
S14: “It improves my imagination. I can make sense of sentences. It improves me to write adventurous stories. It improves my research more.”
S16: “I will develop more if I become a writer or write a book. It improves my thinking. It helps me learn new things. It adds good things.”
S18: “I learn new vocabulary and new mani. When I research their meaning, I learn their definition. I improve myself while writing a story.”

Codes are obtained under the category of “text analysis” related to the “cognitive aims” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they can write text types, understand text types, and determine the topic and main idea of the text thanks to writing activities. Some of the student views are given below.

S2: “As I write, I can understand the feelings of the poet in the text or poem. As I write, my skill of finding the main idea has improved.”

S7: "I learn how to develop the beginning and the end of stories. I learn how to connect parts of stories."
S11: "How to write a story, how to write a fairy tale? It helps me to learn them."
S13: "It improves me in terms of thinking and imagination. It improves me in writing essay."
S19: "I improve in terms of writing beautifully. Reading, comprehension, finding main ideas and topics are improved."

Codes are obtained under the category of "vocabulary" related to the "cognitive aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they learn new vocabulary, are able to make sentences, and speak fluently thanks to writing activities. Some of the student opinions are given below.

S7: "I learn new vocabulary. I can use vocabulary correctly when I need to write a text."
S8: "I think that I have improved myself in the activities of writing poems, texts, and fables in terms of making sentence, using words correctly, and developing vocabulary. I think that my self-confidence improves when I read the texts I have written such as poems and stories."
S15: "It improves my writing skills, helps me to make sentences and speak quickly."

Codes are obtained under the category of "spelling rules" related to the "cognitive aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they are able to use punctuation marks and conjunctions correctly thanks to writing activities. The opinions of the students are given below.

S14: "I was forgetting punctuation marks and -too suffixes in my writing, it helped me to correct them."
S20: "It helps me to write more correctly in spelling."

Codes are obtained under the category of "positive attitude" related to the "affective aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they are happy, feel good, get excited, and enjoy writing while doing writing activities. Some of the student views are given below.

S11: "I enjoy writing articles, stories, poems, and anecdotes. I feel peaceful and happy."
S13: "I am very happy, I like it. For example, if I read or write a story, I am looking forward to the end. It develops my sense of curiosity. I think about how to connect the events."
S20: "When I write stories and poems, I think more about my memories. I like telling my memories very much. I like reading and writing activities very much."

S21: "I feel as if I am writing my own life. I feel good while I write a diary. I feel happy because I express myself through writing. I also feel joy and happiness while I write fables and fairy tales."

Codes are obtained under the category of "negative attitude" related to the "affective aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they do not want to write on topics that do not interest them and they are bored while doing writing activities. Some of the student views are given below.

S6: "I get bored when there are too many writing activities. It is good if it is enough not to force me."
S18: "I don't like to write if I don't like the story at all."
S19: "I sometimes experience feelings of boredom. I get bored when I write about topics that do not interest me."

Codes are obtained under the category of "anxiety" related to the "affective aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have expressed that they are worried that they could not understand the writing topic, they are afraid that they could not write the given topic, they think that their writing will not be liked and they have difficulty expressing their feelings.

S2: "I worry that I will write incorrectly while writing."
S7: "When a new topic comes, I sometimes get anxious because I don't know how to connect it."
S8: "When I have no knowledge or idea about what I am going to write about, I get anxious that I will not be able to write."
S12: "There are times when I get anxious. I worry about what I should add to the writing and what kind of narrative style I should apply. Actually, I worry if it will not be liked."
S15: "I have difficulty in getting inspiration, I worry a lot."
S20: "I sometimes get anxious. For example, when I write a memory, it might be difficult for me to express my feelings to the other person."

Codes are obtained under the category of "writing skills" related to the "psychomotor aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that their writing skills improve thanks to writing activities and that they could write beautifully and fluently. Some of the student views are given below.

S3: "Writing activities improve my imagination. It improves our hand to get used to writing more. Because the more our hand writes, the more we want to write."
S6: "My writing improves, then I can write fast and I have learned."
S11: "It improves my ability to write and express myself. I can feel like a writer when there are writing activities."

S21: "Writing has improved me in every aspect. My patience in writing something has improved. It has improved my writing habit. It has improved my ability to write well and not to get bored while writing."

Codes are obtained under the category of "pencil holding skills" related to the "psychomotor aims" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they are able to hold the pencil correctly and their ability to draw picture has improved thanks to writing activities. Some of the student views are given below.

S1: "I improve my writing skills every day and write more beautifully. I can hold the pencil properly."
S5: "It contributes to improving my writing skills. In another way, it can improve my drawing skills. I can draw better because of my pencil hold."

Students' Opinions Related to the Content Element of the Curriculum

The "content" element of the 2019 Turkish curriculum fourth grade writing skills learning field is analyzed in three themes: "Usefulness", "relevance to interests and needs" and "learnability". In the "usefulness" theme, three categories are obtained "writing text types", "using in out of school environments" and "using in evaluation activities". In the "relevance to interests and needs" theme, three categories are obtained "level of attractiveness", "interesting text types" and "interesting topics". In the "learnability" theme, two categories are obtained "current difficulty level" and "suggested difficulty level". Codes and categories related to the themes are given in Table 2.

Table 2 Codes, categories and themes related to the content element of the curriculum

Theme	Category	Code	f
Usefulness	Writing text types	Writing a letter	3
		Writing a poem	2
		Writing a diary	2
		Writing a petition	1
	Using in out of school environments	Sharing knowledge with family members	6
		Using learned vocabulary	5
		Helping your friends	3
		Use in games	3
		Using proverbs	2
		Transferring the main idea of the texts to their daily lives	1
	Using in evaluation activities	Answering questions	4
		Use when doing homework	3
		Use in exams	3
		Use in other lessons	1
		Use in competitions	1

Relevance to interests and needs	Level of attractiveness	The topics are mostly interesting	14
		The topics are partly interesting	4
		Topics are not of interest	3
	Interesting text types	Poem	10
		Story	9
		The fairy tale	7
		Fable	5
		Essay	5
		Anecdote	4
		Nursery rhyme	2
	Interesting topics	Topics related to living creatures	10
		National culture	10
		Topics related to values education	9
		Topics related to the environment	8
		Topics related to technology	6
		Biography from people's lives	5
		Topics to develop thinking skills	5
		Topics in history	5
		Topics in science	5
		Topics related to our world	4
		Topics related to space	4
		Diseases	2
		Topics related to daily life	2
Learnability	Current difficulty level	The level of topics is medium difficulty	11
		The level of topics is easy	8
		The level of the topics is difficult	2
	Suggested difficulty level	The level of the topics should be of medium difficulty	11
		The level of the topics should be difficult	7
		The level of topics should be easy	2

Codes are obtained under the category of “writing text types” related to the “usefulness” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they use what they have learned while writing letters, poems, diaries, and petitions in their daily lives. Some of the student views are given below.

S3: “For example, I need to write a letter to a person far away. I get information from what we do in lessons and I write accordingly. I write poems. I understand how the tones will be in poems and how the verses can fit together. Since we do it ourselves, the texts stay in my mind more.”
S5: “It is useful in writing activities such as writing poems and letters.”
S17: “I sometimes feel like writing something and I use it there. I use it for writing letters. I have a foreign friend abroad. I wrote a few letters to him. I sometimes keep a diary. I learned how to write a petition.”

Codes are obtained under the category of “using in out of school environments” related to the “usefulness” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they use what they have learned in writing activities while helping their friends, sharing their knowledge with family members, using words and proverbs in accordance with their meanings, playing games and transferring the admonitions they have learned from the texts to their lives. Some of the student opinions are given below.

> *S10: "I mostly use the admonitions I have learned in stories and fairy tales. They correct people a little more. I use what I have learned more on the street. When I play with my friends, I respect them."*
> *S13: "When an event happens, I can use my imagination about how it happened, how it developed, and what it resulted in. I can transfer these to my friends. My stories are usually good. My brother consults me when he writes theatre texts and plays scripts. I use it in this way in daily life."*
> *S18: "Proverbs appear in the texts. I can use them in daily life such as "drop by drop becomes a lake", "strength comes from unity", "hide the straw and the time will come", and "the tree bends while it is young". I use the proverb "one hand has nothing and two hands have sound" a lot when I play games. I sometimes learn words I do not know, I use them. I have learned the meaning of manis I do not know."*
> *S20: "If a friend has written wrongly or if there are mistakes in my own writing, I correct them. What I have learned is useful, when I write to my mother, father, or brother."*

Codes are obtained under the category of "using in evaluation activities" related to the "usefulness" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they use what they have learned in writing activities while answering questions, doing homework, exams, other lessons, and competitions. Some of the student views are given below.

> *S9: "When I have difficulty with English words, I write four or five times. My writing becomes very good afterward. I can write the word."*
> *S11: "For example, I use what I have learned in the informative text when the teacher asks a question or to tell someone something. I share it with my siblings and my family. I transfer information to them. When they tell others, the information spreads."*
> *S14: "We organize story writing competitions as a class. I use it in competitions. I use it in my story writing homework. I can answer the questions asked by my teacher better."*
> *S19: "I use what I have learned, when I study for exams or when we have a written test on a story."*

Codes are obtained under the category of "level of attractiveness" related to "relevance to interests and needs" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, writing topics are interesting to most of the students, partially interesting to some of the students, and not interesting to some of the students. Some of the student opinions are given below.

> *S6: "We are given a text and asked what the topic of the text is. We try to find it. These do not interest me much."*
> *S15: "Sometimes I am interested, sometimes I am not. I am interested, when it is about microscopic creatures. Stories do not interest me."*

S17: "I am not interested. We love technology. I would like to have information about technology and games in the curriculum. I would like to write the rules of the game we design ourselves."
S20: "I can say that the topics interest me. I like to write adventure stories and fables. I like to determine the topics and main ideas of the stories in the Turkish textbook or to write the stories in our notebooks. I learn more while writing."

Codes are obtained under the category of "interesting text types" related to the "relevance to interests and needs" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that writing activities in the types of anecdote, story, fairy tale, fable, nursery rhyme, poem, and essay attract their attention. Some of the student opinions are given below.

S2: "We wrote a science and technology poem, there was a nursery rhyme. I was very interested in them. There was a fable, the admonition we learned in the fable was very good. There was a fable about a hare and a tortoise. I was very interested in that."
S4: "Story elements are given. We create new stories. I like that very much. I like acrostic poems, fairy tales, and fables very much."
S11: "I am more interested in anecdotes and fairy tales in writing activities. For example, Nasreddin Hodja's anecdotes make us think, teach us an admonition and make us laugh. That is why I like anecdotes very much. Since fairy tales are more imaginative, my imagination develops and it is nice to read and listen to them."
S21: "We wrote an essay about the Ramadan feast. I was very interested in it and I wrote it very lovingly. I am interested in poetry, fables, stories, and fairy tales."

Codes are obtained under the category of "interesting topics" related to the "relevance to interests and needs" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that topics related to environment, living creatures, values education, biography from people's lives, thinking skills, science, technology, diseases, history, national culture, world, space, and daily life are interesting. Some of the student opinions are given below.

S3: "There was one poem. It was about the pollution of the world. I wrote it in my notebook and on the computer. I am very interested in environmental problems and issues related to love in the world. The topics related to values and our national culture should be added to the curriculum. Atatürk's life, traditional features, traditional food, and traditional clothes should be added. In relation to values, topics about how people can be happy and how they can behave more properly should be added."
S7: "I like to write about events that happen in myself and in the environment. I write about discrimination among people, and diseases. I write about the events of a girl's school life."
S8: "I like topics related to nature, peace, friendship, and love. Topics such as technology addiction, art, nature, love of books, and love of homeland should be added."
S10: "Essay and fairy tales are more interesting for children. I am more interested in the life of animals, the survival of animals, the life of scientists, extinct animals, and Ottoman history."

S19: "I like more scientific things. For example, I like to write about space. I am also interested in art. I like to write about Leonardo da Vinci. Nature and universe topics interest me. I am also interested in national culture."

Codes are obtained under the category of "current difficulty level" related to the "learnability" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, half of the students have stated that the difficulty level of writing topics is at the medium level, almost half of the students have stated that it is at the easy level, and some of the students have stated that it is at the difficult level. Some of the student views are given below.

S3: "Writing activities are not difficult for me because I like writing. Writing activities can make us think more. When we immediately think of it, it is simple. When it is directed towards thinking, we both use our imagination more and we write longer and more beautiful information."
S5: "Writing activities are not difficult. In terms of difficulty level, it should be from easy to difficult and according to students' skills. It would be better to determine the level of students from easy to difficult. You should give homework according to them."
S7: "When I write, I have difficulty in detailed topics. For example, when I write something about a disease, I have difficulty because I have to write every detail of it."
S12: "I do not have difficulty in writing, I think it is easy. They do not give difficult topics in class."
S17: "In my opinion, the difficulty of writing activities is at medium level. If you prepare something above easy, students will like it. Make it a little below the middle."

Codes are obtained under the category of "suggested difficulty level" related to the "learnability" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, half of the students have stated that the difficulty level of the writing topics in the curriculum should be prepared at the medium level, almost half of the students have stated that it should be at the difficult level, and some of the students have stated that it should be at the easy level. Some of the students' opinions are given below.

S2: "In my opinion, writing topics should be more difficult. Because we are fourth grade students, we can understand some things better. Therefore, it should be at our level."
S8: "It might be better if you prepare the activities at a difficult level, we think more when we have difficulty."
S9: "Sometimes there are times when I write slowly. My hand hurts a lot. I want to leave it for two seconds and then I am late. It is a bit difficult for me. I think some people do not like to write a lot. For example, there are those who get tired like me when I write a little. Therefore, medium level is suitable for everyone."
S19: "Sometimes I have difficulty, sometimes I don't. I have difficulty in long topics. I do not have difficulty in short topics. I want it to be easy."

Students' Opinions Related to the Learning Experiences Element of the Curriculum

The “learning experiences” element of the 2019 Turkish curriculum fourth grade writing skills learning field is analyzed in four themes: “Time”, “tools and equipment”, “methods and techniques” and “classroom environment”. In the “time” theme, two categories are obtained “available time” and “suggested time”. In the “tools and equipment” theme, two categories are obtained “available material” and “suggested material”. In the “methods and techniques” theme, three categories are determined “individual teaching”, “group teaching” and “writing techniques”. In the “classroom environment” theme, two categories are obtained “communication with the teacher” and “communication with peers”. Codes and categories related to the themes are given in Table 3.

Table 3 Codes, categories and themes related to the learning experiences element of the curriculum

Theme	Category	Code	f
Time	Available time	Less than 30 minutes is given	10
		More than 30 minutes are given	8
		Writing activities are given as homework	5
	Suggested time	More than 30 minutes should be given	15
		Less than 30 minutes should be given	5
Tools and equipment	Available material	Stationery materials	19
		Visual and audio material	7
		Written material	6
	Suggested material	Stationery materials	17
		Visual material	8
		Three-dimensional material	5
		Visual and audio material	2
		Written material	2
Methods and techniques	Individual teaching	Individual study	15
		Homework	5
	Group teaching	Dictation practice	7
		Drama	6
		Question and answer	5
		Narration	4
		Discussion	1
		Brainstorming	1
		Station	1
	Writing techniques	Group writing	5
		Creative writing	3
		Creating a story	3
		Free writing	2
		Text completion	1
Classroom environment	Communication with the teacher	Asking questions to the teacher about the written topic	17
		Teacher giving feedback	9
		Teacher giving reinforcement	5
	Communication with peers	Exchange ideas with friends	14
		Lack of effective communication process with friends	6

Codes are obtained under the category of "available time" related to the "time" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, half of the students have stated that writing activities are allocated less than 30 minutes, some of the students have stated that writing activities are allocated more than 30 minutes, and some of the students have stated that writing activities are given as homework. Some of the student opinions are given below.

> *S8: "We are given one lesson hour, that is 40 minutes. It is enough, but we sometimes may not think of something, it is better to think a lot. When nothing comes to mind, this time should be extended a little more."*
> *S16: "The teacher gives between 20 and 25 minutes. Those who finish early in this period explain with pictures. This time is enough for me."*
> *S19: "Actually, there is no specific time. The teacher usually gives homework. Actually, the time varies depending on the length of the type of writing. If the writing is long, the time should be long. If it is short, the time should be short. The time should be determined according to the type of writing."*

Codes are obtained under the category of "suggested time" related to the "time" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while the majority of the students have stated that more than 30 minutes should be given to writing activities, some of the students have stated that less than 30 minutes should be given. Some of the student views are given below.

> *S3: "Since writing activities are usually left to the end, we write at home. When we do it at school, we are given between 5 and 10 minutes. I want to write more, but I cannot think of much in this time. Therefore, I can write a poem of one or two stanzas, or a text of one or two chapters. In fact, since writing activities are important, they should be given half a lesson hour. The time should be between 20 and 25 minutes."*
> *S15: "Give time according to students' personality and speed. I think at least 30 minutes should be given. Sometimes in between 20 and 25 minutes, you cannot fully express the emotion, the text is incomplete."*
> *S18: "If we give little time, the students may not write in a hurry. If we give too much time, they will say that we have too much time and we will write later. I think it is right at medium, that is, a maximum of 40 minutes should be given, at least 20 minutes can be given."*

Codes are obtained under the category of "available material" related to the "tools and equipment" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they use different types of pencils, paper, notebooks, erasers, dictionaries, books, computers, rulers, boards, and sharpeners in writing activities. Some of the student views are given below.

S9: "I look up words I do not know from the dictionary. I do not want to write the same words all the time. I want to write a different meaning of the word. When I use unlined paper, I need a ruler to avoid writing crookedly. If I want to draw something next to it, I use colored pencils."
S11: "We use a dictionary to look up the meaning of a word. We use tools such as tablets, computers and phones to do research at home. The teacher sometimes hangs it on the board, then we use A4 paper. If we write in our notebooks, we use lined paper."
S16: "We use textbooks, poem books, story books and smart boards."
S19: "I use pencil, notebook and eraser. If I want to draw a picture in the writing activity, I use crayons. I use a sharpener."

Codes are obtained under the category of "suggested material" related to the "tools and equipment" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that different types of pencils, different types of papers, visuals on the topic, puppets, sample books, decoration materials, notebooks, rulers, erasers, glues, boards, cardboards, videos on the topic, computers, models, sharpeners, and scissors are necessary for writing activities. Some of the student opinions are given below.

S5: "With rulers, fancy objects, colored pencils and highlighters, we can keep what we write in our minds and our notebook also looks beautiful. You should keep crayons. You should have them write a text and then draw a picture related to that text. Both their drawing skills and their writing skills will improve."
S7: "There should be a visual, the students should write a story about that visual. There should be a device for research. There should be a special notebook for children, they should write in it. For example, there should be a silent film, they should write about it."
S11: "For example, there should be a model about a topic. For example, if we write something about birds, there should be models about birds or there should be visuals with the information written underneath. For example, the students should make things related to Turkish topics from papers and cartons, and hang them on the boards."
S15: "It should be colored pencils, books with pictures or just pictures. You should give examples of how to do it with pictures. There should be puppets, the lesson will be more fun and memorable."
S19: "There should be basic things in your classroom so that children can write. The type of writing should be fun. You should write topics that students will like. The writing should not be too long. There should be pencil, paper, notebook if the paper is not used, eraser, red pencil, sharpener, and other pencils."

Codes are obtained under the category of "individual teaching" related to the "methods and techniques" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while the majority of the students have stated that they have carried out writing activities individually in the classroom, some of the students have stated that they do it as homework. Some of the student views are given below.

S8: "Our teacher tells us the topic and we write. We write alone for one lesson period. In the next lesson, we read what we have written. We tell what we have written and we sometimes act out what we have written."
S17: "Our teacher gives homework. We read the activities we do according to the seating order. If we design something, we show it and introduce it to our friends. We sometimes act out. Most of the time we do it individually."
S19: "When the teacher wants to explain a topic, he writes an informative text on the board. Then we write that topic in the notebook. We also do the beautiful writing activities in the book. Actually, we do not do it in groups in class, we usually do it individually. We usually do writing activities with homework."

Codes are obtained under the category of "group teaching" related to the "methods and techniques" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they use drama, narration, question and answer, dictation, discussion, brainstorming, and station techniques while doing writing activities. Some of the student views are given below.

S2: "Our teacher tells us the topic, event, character, place, and time. We write the stories in our notebooks or on paper according to them. She sometimes writes them on the blackboard and she sometimes reads them. We write them in our notebooks. We practice dictation."
S5: "For example, if the teacher asks us to make a theatre about animals, we act it out and then write it down. The teacher does question and answer, where we do not understand, he selects a few people and does modelling."
S10: "We share ideas because our class is talkative. For example, I say that I make the story like this, do you have an idea or should we add it? We write articles in our own way. We write our own ideas. The teacher gives us a topic. We write according to our imagination."
S16: "At first, the teacher tells us the topic and then tells us how to do it. He gives us a certain topic from the book and we write articles. We use stations in groups. He changes stations every five minutes. If I am in the poster station first, then I move to the poetry station. For example, on human rights, one group writes a poem, another group makes a poster and the other one group draws a picture."

Codes are obtained under the category of "writing techniques" related to the "methods and techniques" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, it is determined that students use group writing, creative writing, free writing, and text completion techniques while doing writing activities. Some of the student opinions are given below.

S3: "The teacher gave a topic about the forest week, we wrote a poem of two or three stanzas with it. He made us write a text about being disabled, which he left to our own imagination. I wrote something of one or two pages."
S9: "The teacher writes half of the text on the blackboard and tells us to complete the rest. He sometimes gives a topic and tells us to write about it. We also do writing activities in groups. For example, when the teacher wants us to write a difficult topic, we do it in

> *groups of two, three, or four students. He wants us to think on our own when we write acrostic poems."*
> *S14: "We usually write in groups. Our groups are five or six people. The teacher sometimes gives the topic to the group, she sometimes asks us to determine the topic as a group. We write according to our imagination."*

Codes are obtained under the category of "communication with the teacher" related to the "classroom environment" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that they ask questions to their teachers during writing activities and the teachers give reinforcement and feedback. Some of the student views are given below.

> *S9: "Let's say the writings are a little illogical, the teacher does not want to offend us too much. He says that you can think a little more. We have a sticker chart. He gives stickers for the good behaviors we do. If we pass the 30th grade, he gives us a gift. If we do well, he congratulates us and gives us stickers."*
> *S13: "When our stories are finished, our teacher tells us to take them to her and read them. She sometimes comes and reads our stories before they are finished and gives her opinions. She says things like it is good or you can remove this or add this. I ask them if we have any questions. For example, after writing the introduction of our story, I ask how I can write the development or conclusion section."*
> *S20: "We ask our teacher what the topic and main idea will be. She tells us which topic our story or fable is about. She can also give another topic to those who write poems."*

Codes are obtained under the category of "communication with peers" related to the "classroom environment" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while more than half of the students have stated that they exchange ideas about the topic they write with their friends during the writing activities, some of the students have stated that they do not have an effective communication process with their friends. Some of the student views are given below.

> *S13: "We look at each other's stories and tell our ideas. We tell what they can add and what can happen next."*
> *S15: We give ideas to our friends about how we can write, and how we can decorate it. They say that if you write paragraph by paragraph, it will be clearer and you can see what you write more easily, you can read it more easily".*
> *S16: "Everyone has their own book. Everyone writes their own answer. In class discussions, students think a little bit. Then they raise their fingers when they think of something. The one chosen by the teacher gets up and says her opinion. Everyone says their own opinion. There is not much discussion among ourselves, we do not communicate. When we do not understand, we ask our teacher."*
> *S19: "We do not ask our friends many questions. We do not work in groups. If we did activities in groups, we would ask. Only when we move on to a new topic, the teacher makes us write in the notebook. We usually do writing activities at home."*

Students' Opinions Related to the Evaluation Element of the Curriculum

The “evaluation” element of the 2019 Turkish curriculum fourth grade writing skills learning field is examined in two themes: “Assessment type” and “post writing stage”. In the “assessment type” theme, two categories are obtained “traditional assessment” and “alternative assessment”. In the “post-writing stage” theme, two categories are obtained “correction” and “sharing”. The codes and categories related to the themes are given in Table 4.

Table 4 Codes, categories and themes related to evaluation element of the curriculum

Theme	Category	Code	f
Assessment type	Traditional assessment	Multiple choice exam	1
		Verbal exam	1
	Alternative assessment	Peer assessment	12
		Self-assessment	3
Post writing stage	Correction	In terms of topic and content	15
		In terms of spelling and punctuation	7
		In terms of language and expression	6
		In terms of form	5
	Sharing	Presenting the text	12

Codes are obtained under the category of “traditional assessment” related to the “assessment type” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, some of the students have stated that writing activities are evaluated by exams. Student opinions are presented below.

> *S1: “After the writing activities, we can do what we have learned very well in mock exams. In the mock exams, they may ask questions such as whether this is an anecdote, a fairy tale, a story, a fable, or a poem. We are able to answer these questions thanks to writing activities.”*
> *S21: “The teacher makes them take the verbal exam. He asks questions one by one. When there are words we do not know, we look them up in the dictionary and read them one by one. For example, there were words I did not know in the essay we wrote. I found the word in the dictionary and read it. Our teacher asked us to produce questions from there. We solved the problems in that question.”*

Codes are obtained under the category of “alternative assessment” related to the “assessment type” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while half of the students have stated that peer assessment is used in the evaluation of writing activities, some of the students have stated that self-assessment is used. Some of the student views are presented below.

S3: "After the activities, we read our poems to each other and share them with our teacher. We discuss what we add to the poem and what is unnecessary in the poem. We talk and comment on these issues. We usually look at the titles and the harmonies between paragraphs."
S14: "We write the story and finish it. Before showing it to the teacher, if we have spelling mistakes, if we forget to write a sentence, we correct them. If the visuals are incomplete, we complete them. Our friends say that you should have done the visuals like this, you should have written the story here on other topics. They give opinions about the characters."
S20: "How can it be better, is this good, is this lacking, what else can we do? We discuss these. Our teacher wants us to develop our imagination. I like it when my friends express my mistakes. Because I may be a columnist in the future. Therefore, it is good for me to see my mistakes."

Codes are obtained under the category of "correction" related to the "post-writing stage" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that writing activities are evaluated in terms of topic and content; spelling rules and punctuation; language and expression; and form. Some of the student views are presented below.

S4: "When we use some words in the wrong place, the teacher says that it would be more effective if you used that word in another place. For example, there is a very well-known word, if we used it, the expression would be much better. She pays attention to such things. Is it relevant to the topic? She looks at these things."
S10: "When writing a poem, the teacher looks more at the main emotion. When writing a fairy tale, is it more appropriate to the topic or not? She evaluates accordingly. If you write one or two lines on a topic or you go out of the topic, then your writing is bad."
S11: "The teacher points out the good aspects of our text and the semantic errors in the sentence. She says that the writing is better if we explain the narration style and the topic comprehensively. For example, if we write two sentences, she says that you should have made it a little longer. She evaluates the introduction, development, and conclusion sections. For example, do we write a sentence suitable for the introduction, do we write sentences suitable for the development, or do we connect the conclusion with the admonition we learned? She evaluates them."
S14: "If we have deficiencies, the teacher tells us our deficiencies. If we do not have deficiencies, he says that it is good and hangs it on the board. He evaluates by looking at spelling mistakes, punctuation marks, topic, and main idea. He tells us to improve the topic a little more, improve your imagination, write a little longer, and improve the visuals a little more".
S18: "The teacher tells us to write at least two paragraphs or at least four paragraphs. She looks at them. She looks at the beauty of our writing. Do we have spelling mistakes? She looks at it."

Codes are obtained under the category of "sharing" related to the "post-writing stage" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, half of the students have stated that they present their study after completing the writing activities. Some of the student views are presented below.

S6: "We raise our fingers and the student selected by the teacher reads his/her writing. If there are any mistakes, the teacher tells us to correct them. For example, once we were given a proverb. She told us to write down what it could mean. Everyone wrote it down, and if the teacher found a mistake, she corrected it."
S7: "We read in class. The teacher says that it is good or you should continue. If there is a different topic or a different emotion transition, our teacher likes them. She looks at where the time passes. If it is in the present or past tense, we use it accordingly.
S15: "The teacher collects what we have written and gives them back to us after a few days. We go up to the board and read them, determine our mistakes, and be more careful next time. Our teacher tells us our mistakes. When she sees a mistake while distributing the text, she says that you can correct this. If we read fast, she says that you should read slowly, it is better understood."

Students' Opinions Related to the Positive and Negative Aspects of the Curriculum

The "positive and negative aspects" theme of the 2019 Turkish curriculum fourth grade writing skills learning field is examined in two categories "strengths" and "weaknesses". Codes and categories related to the theme are presented in Table 5.

Table 5 Codes and categories related to the "positive and negative aspects" theme of the curriculum

Theme	Category	Code	f
Positive and negative aspects	Strengths	Allowing to write different types of texts	9
		Being interesting of the given topic	9
		Allowing to analyze texts	3
		Providing the opportunity to enrich texts with visuals	3
		Teaching new words	2
		Developing imagination	1
	Weaknesses	Inadequate writing activities	8
		Being not attractive of the activities	5
		Not providing enough information about the activities	4
		Dislike of dictation activities	3
		Unknown or incomprehensible topic matter	3
		Spelling and punctuation errors	3
		Not using different writing methods	2
		Insufficient space allocated for writing	2
		Writing activities are not related to the unit	1
		Repeated statements	1
		Inadequate evaluation	1

Codes are obtained under the category of "strengths" related to the "positive and negative aspects" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while almost half of the students like the aspects that the curriculum allows them to write different types of texts and that the topics are interesting, some of the students like the aspects that the curriculum allows them to analyze the texts, provides the opportunity to enrich the texts with visuals, teaches new words and develops imagination. Some of the student opinions are presented below.

S3: "I like the parts that develop our imagination more and require us to use our imagination more."
S5: "I like poem sections, stories, and puppet plays like Karagöz and Hacivat. I have an interest in these. There are pictures, I try to draw them, it is very nice."
S7: "In the book, they tell us to write a story. When we write that part in the notebook, the topics they give attract my attention. I write inspired by the texts they give me, I like the texts."
S10: "In writing activities, I like determining the topic and main emotion of the text more. You can write not only one title but also the title you think of yourself. I also like this."
S20: "It is good for me when we write a poem and a story about a topic. I like that it encourages us to search for words we do not know and look them up in the dictionary. We are given space in the book to write stories and poems I like and we write them there. I like this very much, it means that they value our ideas. I also like to find topics and main ideas."

Codes are obtained under the category of "weaknesses" related to the "positive and negative aspects" theme of 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while almost half of the students have stated that the writing activities in the curriculum are insufficient, some of the students have stated that the activities are not interesting, there is not enough information about the activities, dictation activities are not liked, different writing methods are not used, there are spelling and punctuation errors, unknown or incomprehensible topics are included, the spaces allocated for writing are insufficient, writing activities are not related to the unit, there are repetitive explanations and the evaluation is insufficient. Some of the student opinions are presented below.

S3: "Sometimes a comma can be put instead of a dot or there can be uppercase and lowercase mistakes. There may be words that do not fit each other. There may be too many gaps between sentences and the meaning of that text or poem is spoilt. I think activities should be increased. I would be very happy if there was a short writing activity between one or two activities. There are not usually activities related to the topics in the unit. For example, our theme is national culture, but there are things related to the outside world instead of local things. I would like the main topic in that unit to be added."
S5: "Information that is explained in the text is explained again underneath. This makes me very angry. It is already explained in brackets, why is it explained again underneath?"
S13: "There is usually one writing activity in each unit, I would like to see more writing. We are only given a topic, but I would like to be given a story and told to come up with appropriate titles and what we can add to it. It would be very nice if they gave us the introduction part of the story and we wrote the rest."
S15: "Instead of being given a blank paper, it is given like the writing correction places in first grade. I find it difficult to write there because there is a perception that I have to fit it there. Instead of giving small boxes, I should be given an activity space. I would like it more and write more easily. For example, we wrote a poem and the stanzas of the poem

did not fit in the space provided. Writing activities are not enough, it is given less space than necessary.”
S17: “One poem is given. It says to write that poem on the right. I do not like it. It is already written, why are we writing it again? It would be more meaningful if there were questions about the poem.”
S21: “It briefly moves on to the next topic without explaining one topic. There is not much evaluation. There are words we do not know, we cannot find them in the dictionary.”

Students' Opinions Related to the Suggestions of the Curriculum

The “suggestions” theme of the 2019 Turkish curriculum fourth grade writing skills learning field is examined in four categories: “Suggested objectives”, “suggested content”, “suggested learning experiences” and “suggested evaluation”. Codes and categories related to the theme are presented in Table 6.

Table 6 Codes and categories related to the “suggestions” theme of the curriculum

Theme	Category	Code	f
Suggestions	Suggested objectives	Developing writing skills	16
		Developing imagination	7
		Teaching new information about the topics of Turkish lesson	7
		To teach basic information about text types	5
		Developing sentence making skills	4
		Developing the ability to inquiry	4
		Teaching information about punctuation and spelling rules	3
		Teaching new vocabulary	3
		Developing expression skills with visuals	3
		Developing self-expression skills	2
		Developing research skills	2
		Developing presentation skills	2
		Developing comprehension skills	2
		Developing communication skills	1
		Developing creativity	1

	Suggested content	Writing topics in different text types (Fable, f=12; poem, f=9; story, f=8; informative text, f=7; anecdote, f=6; fairy tale, f=4; theatre, f=5; nursery rhyme, f=3; essay, f=3; comics, f=3; caricature, f=1)	21
		Topics related to the life of living creatures (Life of animals, f=8; protection of animals, f=4; characteristics of animals, f=3; endangered animals, f=2; living creatures in water, f=2; life of plants, f=1)	20
		Topics related to values education (Love, f=5; friendship, f=4; helpfulness, f=3; patriotism, f=3; respect, f=1; justice, f=1; honesty, f=1; responsibility, f=1)	19
		Topics related to our culture (National struggle, f= 6; national culture, f=5; child games, f=3; Atatürk's life, f=2)	16
		Issues related to nature (Protection of nature, f=6; environmental pollution, f=4; forests, f=3)	13
		Topics related to the world and the universe (Space and astronomy, f=6, planets, f=4; fossils, f=1)	11
		Topics related to technology (Conscious use of technology, f=4; change of technological products from past to present, f=3, benefits and harms of technology, f=2; features of technological devices, f=2)	11
		Topics related to science (Life of scientists, f=5; inventions of scientists, f=3)	8
		Topics related to daily life	3
		Topics related to family relationships	2
		Topics related to art	2
		Topics related to professions	1
		Topics related to sport	1
	Suggested learning experiences	Questions about the text	13
		Explaining the text with pictures	10
		Finding the topic and main idea of the text	7
		Activities for teaching the meaning of words	4
		Summarization activities	4
		Dramatizing the text	4
		Creating three-dimensional designs related to the text	3
		Finding a title for the text	2
		Designing a poster with Web 2 tools	1
		Completing unfinished text	1
		Rewriting the text in a different text type	1
		Activities related to spelling and punctuation	1
	Suggested evaluation	Assessment of punctuation and spelling rules	14
		Assessment of the expression of the topic and the main idea	9
		Assessment of the beauty of the writing	8
		Assessment of the use of words and sentences	6
		Assessment of the harmonization of the text sections	4
		Open-ended questions	4
		Assessment of the harmonization of the title with the topic	3
		Peer assessment	3
		Self-assessment	2
		Assessment of the spelling of suffixes	2
		Matching questions	1
		True-false questions	1

Codes are obtained under the category of “suggested objectives” related to the “suggestions” theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while most of the students have stated that their writing skills should be improved, almost half of the students have stated that their imagination should be developed and new information about the topics of the Turkish lesson should be taught. On the other hand, some of the students have stated that information about text types, and punctuation and spelling rules should be taught; new words should be taught; inquiry, making sentence, expression with visuals, self-expression, research, presentation, comprehension, communication skills and creativity should be developed. Some of the student opinions are presented below.

S3: "Forming with visuals or colors and writing texts from them should be added. Apart from these features, I would like it to provide me more information that can open to the world of imagination. I would like it to develop my creativity."
S8: "Improving writing skills, learning new words, adding new words to our vocabulary, and using these words correctly in sentences should be gained."
S11: "How can a story and informative text be written? You should help them understand these better. For example, narrative skills should be developed while writing a story. How are the introduction, development and conclusion sections connected to each other? This should be taught."
S17: "Give research homework to students. When you give poem writing homework, tell them how to write the poem and then give it to them. Teach things like writing skills, spelling rules, and correct writing. I would like them to be given homework related to technology. I would like them to improve their slide preparation skills."
S20: "More often spelling and grammar rules are not paid attention to. It would be better to improve in this matter. It would be better to develop our imagination and express ourselves. It would be more effective to act out the activities and stories. I would like to write my feelings more effectively and clearly. I think my friends would also like to improve in this aspect. I would like you to develop the curriculum in this aspect."

Codes are obtained under the category of "suggested content" related to the "suggestions" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, students have stated that texts should be written in the types of fable, poem, story, informative text, anecdote, fairy tale, theatre, nursery rhyme, essay, comics, and caricature. The students have stated that the text topics should be space and astronomy, planets, fossils, national struggle, national culture, Atatürk's life, child games, love, friendship, helpfulness, patriotism, respect, justice, honesty, responsibility, conscious use of technology, change of technological products from past to present, benefits and harms of technology, features of technological tools, life of scientists, inventions of scientists, life of animals, protection of animals, characteristics of animals, endangered animals, living creatures in water, life of plants, protection of nature, environmental pollution, forests, issues related to daily life, family relations, arts, sports, and professions. Some of the student opinions are presented below.

S11: "It should be about our culture, Karagöz and Hacivat, Nasreddin Hodja, nature, animals, technology, the life of the inventors of an invention, how those inventors made efforts to make that invention, how an invention has changed from the past to the present, what life is like in nature, and forests. It would be better if we learn about our own culture, we will encounter it in our lives."

S12: "There should be texts from which admonition can be learned and meaning can be inferred. There should be topics related to family and friend relations. For example, it should be the right choice of friends. There should be a text about space. There should be planets. There should be instructive and informative texts. There should be texts describing the characteristics of animals."

S18: "I like to write informative texts. You should write texts appropriate to the level of the students. They can write poems, fables or texts. There should be topics about the benefits and harms of technology, products used in the past, important materials we use in our daily lives, professions, animals, environmental cleaning and the protection of nature. For example, they should research and write about the giraffe. They learn the properties of animals."

S19: "There should be anecdotes, interesting and informative texts. There should be general history topics and our national culture. There should be about mechanics. There should be the operation, construction, and properties of a tool. There should be topics about the science, space, nature, the life of living creatures, oceans, seas, fish, and animals."

S21: "I would like to write texts on fables, poems, and nursery rhymes. I would like science and technology topics to be added. I would like nature and universe topics. National struggle and the life of Atatürk should be the topic. There should be topics about forests and animal life. You should write the chronological order of the Battle of Sakarya. You should write the introduction of our foods and clothes as national culture."

Codes are obtained under the category of "suggested learning experiences" related to the "suggestions" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while most of the students have stated that there should be activity questions related to the text, almost half of the students have stated that there should be activities for explaining the text with pictures, and finding the topic and main idea of the text. Some of the students have stated that there should be activities for teaching the meaning of words, creating a three-dimensional design for the text, finding a title for the text, summarization, dramatizing the text, designing a poster with Web 2 tools, completing the unfinished text, rewriting the text in a different text type, and spelling and punctuation. Some of the student opinions are presented below.

S10: "Not only writing is available but also activities are available. For example, you should have them write a story about a topic and have them paint about the hero of the story. There should be poster design from Canva. You should write a story or an informative text about a plant. You should plan to grow that plant as a class."

S13: "Activities such as writing and answering questions according to the story; summarizing the story briefly or writing the main idea; completing the unfinished story; and turning the story into a fable or poem should be developed."

> *S19: "There should be one or two questions about the activity. There should be activities related to filling in the gaps and punctuation marks in the same text."*
> *S20: "There should be questions about the topic of a story and the values it brings us. You should ask them to research unfamiliar words, and write sentences or stories about them. They should be asked to draw pictures and make projects. You should have them make models that tell the story. It will be more effective to act out the activities and stories."*

Codes are obtained under the category of "suggested evaluation" related to the "suggestions" theme of the 2019 Turkish curriculum fourth grade writing skills learning field. Within the scope of these codes, while most of the students have stated that attention should be paid to punctuation and spelling rules while evaluating writing activities, almost half of the students have stated that the way the topic and main idea are given and the beauty of the writing should be looked at during the evaluation. Some of the students have stated that the evaluation should be done with open-ended questions, matching, true-false, self-assessment, and peer assessment. Some of the students have stated that while evaluating the writing activities, attention should be paid to the correct use of words and sentences, the harmony of the text sections with each other, the harmony of the title with the topic, and the correct spelling of the suffixes. Some of the student opinions are presented below.

> *S3: "Time should be given when everyone's activity is finished. The students should read what they have written and should be told what is missing or redundant in their writing. If the meaning is distorted when the plural suffix is added or omitted, those issues should be corrected. In texts or poems, I would like the parts to be connected to each other and mistakes to be corrected. The connections between sentences and paragraphs should be checked."*
> *S4: "There should be questions. You might make spelling mistakes in some places, students correct them. You should do true-false in the book. You should ask them to decide on a different ending for the text."*
> *S7: "Attention should be paid to the main idea, main thought, and topic. Attention should be paid to emotional transitions, spelling rules, and the connection of the introduction, development and conclusion sections."*
> *S12: "What has this study contributed? This should be evaluated. The use of words such as but and yet, and the comprehensiveness of the text should be examined. It should be checked whether punctuation marks have been paid attention to. You should check the narrative style, and the use of words in the right place."*
> *S16: "You should check whether the title is appropriate, whether the picture is relevant to the topic, whether the writing is beautiful, and whether the text type is appropriate for the level of the student. You should check that a question mark should not be put in a place to put an exclamation."*

Conclusions and Suggestions

The conclusions and suggestions reached within the scope of the research are presented below.

Conclusions Related to the Objective Element of the Curriculum

When the curriculum is considered in terms of the "objectives" element, the students have stated that they develop their imagination and thinking skills, increase their knowledge of the topics in the Turkish lesson, provide permanent learning, develop research skills, understand and write text types, and determine the topic and main idea of the text within the scope of 2019 Turkish curriculum fourth grade writing skills. In addition, the students have stated that thanks to the curriculum, they learn new words, are able to make sentences, speak fluently, use punctuation marks and conjunctions correctly, improve their writing skills, write beautifully and fluently, hold the pencil correctly while writing, and improve their ability to draw pictures. Other results obtained within the scope of the research are that students are happy, feel good, get excited, and enjoy writing while doing writing activities. On the other hand, it is determined that the students do not want to write on topics that do not interest them and get bored while doing writing activities, they are worried that the writing topic will not be understood, they are afraid that they will not be able to write on the given topic, they are worried that what they write will not be liked, and they have difficulty in expressing their feelings. In this context, it is determined that students experience anxiety and concern during writing activities. There are studies in the literature that students experience writing anxieties. In the study conducted by Ateş and Akaydın (2015), it is seen that the writing anxiety of secondary school students is at a moderate level. In the study conducted by Yıldız and Ceyhan (2016), it is identified that the writing anxiety of primary school fourth grade students is at a moderate level. In the study conducted by Yılmaz (2019), it is determined that secondary school students experience writing anxiety due to the anxiety of being evaluated by others, having difficulty in determining the topic, and experiencing lack of self-confidence. In the study conducted by Bozgün (2022), it is observed that the writing anxiety levels of primary school fourth grade students are at a moderate level.

In the 2019 Turkish curriculum fourth grade writing skills learning field, the students have emphasized that "the suggested objectives" should develop writing skills and imagination; teach new information about the topics of the Turkish lesson; teach information about text types, punctuation and spelling rules; teach new words; develop creativity, inquiry, sentence-making, expression with visuals, self-expression, research, presentation, comprehension, and communication skills. In this context, students have emphasized the necessity of including objectives that develop writing skills and higher-order thinking skills more and teach knowledge within the scope of Turkish lesson in the curriculum. These results of the research are similar to the results of the studies conducted by Karacaoğlu et al. (2021), Barası and Erdamar (2021), Dilekçi (2022), Kaplan and Demir (2023). In the research conducted by Karacaoğlu et al. (2021), it is concluded that the eighth grade Turkish textbook is relatively sufficient in terms of the writing activities in the Turkish textbooks to provide students with writing skills, but the fifth, sixth and seventh grade textbooks are not fully sufficient for the development of writing skills. It is also concluded that writing activities in Turkish textbooks should include all the objectives in the curriculum equally in order to improve students' writing skills. In the study conducted by Barası and Erdamar (2021), teachers have stated that the Turkish curriculum should give more weight to skills such as critical thinking, learning to learn, and creative thinking; the number of objectives should be reduced and applicability should be increased; the objectives should be distributed evenly according to grade levels and should be updated. In the study conducted by Dilekçi (2022), teachers have stated that the words aimed to be taught to students should be determined and these should be planned according to grade levels and included in the texts in Turkish textbooks. In the study conducted by Kaplan and Demir (2023), it is suggested that the 2019 Turkish curriculum should be revised in terms of providing higher-order thinking skills and the objectives related to language skills should be increased.

Conclusions Related to the Content Element of the Curriculum

When the curriculum is considered in terms of the “content” element, it is determined that while the writing topics are interesting to most of the students, the topics are not interesting to some of the students within the scope of 2019 Turkish curriculum fourth grade writing skills. Among the interesting topics, there are topics related to environment, living creatures, values education, biography from people's lives, thinking skills, science, technology, diseases, history, national culture, world, space, and daily life. In addition, writing activities in the types of anecdotes, stories, fairy tales, fables, nursery rhymes, poems, and essays are found to attract the students' interest. Accordingly, it is concluded that students use what they have learned in Turkish lessons in their daily lives while writing letters, poems, diaries and petitions; they use what they have learned while helping their friends, sharing their knowledge with family members, using words and proverbs in accordance with their meanings, playing games, transferring the admonitions they have learned from the texts to their lives, answering questions, doing homework, exams, other lessons, and competitions. Regarding the difficulty level of these topics, half of the students have stated that they are at the medium level, almost half of the students have said that they are at the easy level and some of the students have mentioned that they are at the difficult level. In this context, it can be said that the writing topics in the curriculum are relatively suitable for the level of students. These results of the study are similar to the results of the research conducted by Direkçi et al. (2019), Özdemir and Akkaya (2020), Karacaoğlu et al. (2021). In the study conducted by Direkçi et al. (2019), when the activities in the 2018 Turkish lesson curriculum fifth, sixth, seventh, and eighth grade textbooks are examined, it is found that the objectives belong to a grade level above or below the grade level in some activities. In the study conducted by Özdemir and Akkaya (2020), when the 2019 Turkish lesson curriculum is evaluated in terms of text type, it is determined that three types of texts, namely narrative, informative and poetry, are generally used in the curriculum and that there are explanations for the narrative text type the most. In the study conducted by Karacaoğlu et al. (2021), it is suggested that writing activities in Turkish textbooks should be prepared by taking into account the basic characteristics of students such as age and development levels as well as values education and students' affective, cognitive and psycho-social development processes. In addition, it is concluded that writing activities belonging to different text types are included in Turkish textbooks.

In the 2019 Turkish curriculum fourth grade writing skills learning field, the students have emphasized that “the suggested content” should include texts in the types of fables, poems, stories, informative texts, anecdotes, fairy tales, theatres, nursery rhymes, essays, comics, and caricature. Accordingly it is concluded that the topics of these texts should be related to space and astronomy, planets, fossils, national struggle, national culture, Atatürk's life, child games, love, friendship, helpfulness, patriotism, respect, justice, honesty, responsibility, conscious use of technology, change of technological products from past to present, benefits and harms of technology, features of technological tools, life of scientists, inventions of scientists, life of animals, protection of animals, characteristics of animals, endangered animals, living creatures in water, life of plants, protection of nature, environmental pollution, forests, issues related to daily life, family relations, arts, sports, and professions. In this context, it is useful to prepare the text types and topics in the curriculum according to the interests and needs of the students. Regarding the difficulty level of these topics, half of the students have stated that they should be prepared at the medium level, almost half of the students have said that they should be prepared at the difficult level, and some of the students have mentioned that they should be prepared at the easy level. Therefore, it is concluded that the writing skills curriculum should be developed in accordance with the developmental level of the students. These results of the study are similar to the results of the studies conducted by Barası and Erdamar (2021), Karacaoğlu et al. (2021), Dilekçi (2022). In the study conducted by Barası and Erdamar (2021), teachers have stated that the Turkish lesson curriculum should be suitable for the interest and age of the students, include distinguished examples of Turkish and world literature, and have content equipped with national and moral values. They have stated that the content of the Turkish curriculum should include interesting, diverse and colorful texts for the development of 21st century skills. In the study conducted by Karacaoğlu et al. (2021), it is shown that writing activities in Turkish textbooks should be designed in a more qualified and gradual developmental way. It is also concluded that Turkish textbooks should include more narrative texts and poem writing activities. In the study conducted by Dilekçi (2022), teachers have stated that the texts in Turkish textbooks should have high literary quality; be compatible with the unit, important days and weeks; be entertaining, instructive, guiding, appropriate to our culture, and develop high-level thinking. Teachers also have emphasized that Turkish textbooks should include different types of texts.

Conclusions Related to the Learning Experiences Element of the Curriculum

When the curriculum is considered in terms of the "learning experiences" element, while the majority of the students have emphasized that the 2019 Turkish curriculum fourth grade writing skills activities are mostly done individually in the classroom, some of the students have stated that writing activities are given as homework. While half of the students have said that less than 30 minutes are given to the writing activities at school, some of the students have mentioned that more than 30 minutes are given. In this context, it can be said that the time given to the writing activities is insufficient. It is concluded that drama, narration, question and answer, dictation, discussion, brainstorming, station, group writing, creative writing, free writing, and text completion methods and techniques are used during writing activities. Accordingly, it is determined that the variety of methods and techniques used in writing activities is insufficient. During the writing activities, it is also identified that students exchange ideas with their friends about the topic they write about, ask questions to their teachers and teachers give reinforcement and feedback. On the other hand, some of the students have stated that they do not have an effective communication process with their friends during the writing activities. In this context, it is useful to increase communication and sharing in the classroom environment to increase the effectiveness of the lesson. Visual and audio materials, stationery materials, and written materials are found to be used during writing activities. It is determined that visual and three-dimensional materials, which increase students' motivation during the lesson, are not used effectively during the activity. These results of the research are similar to the results of the studies conducted by Susar-Kırmızı and Akkaya (2009), Özdemir and Akkaya (2020), Barası and Erdamar (2021), Arcagök (2021), Karacaoğlu et al. (2021), İmrol et al. (2021). In the study conducted by Susar-Kırmızı and Akkaya (2009), teachers have stated that they do not have enough knowledge about methods and approaches and that they have lack of knowledge about the use of materials regarding the problems experienced in the Turkish curriculum. In the study conducted by Özdemir and Akkaya (2020), when the 2019 Turkish curriculum is examined in the context of planning and writing strategies, it is identified that there is no mention of planning in writing education and there is no objective for planning strategies. In the study conducted by Barası and Erdamar (2021), it is determined that teachers experience problems such as lack of physical infrastructure and time, lack of materials, and repetitive, boring and simple activities in the learning-teaching processes of the 2018 Turkish lesson curriculum. In the study conducted by Arcagök (2021), it is concluded that the sixth grade Turkish lesson curriculum is not prepared by taking into account the practices in different learning theories and models. In the study conducted by Karacaoğlu et al. (2021), it is suggested that writing activities in Turkish textbooks should be planned process-oriented and this process should be carried out effectively under the guidance of the teacher. In the study conducted by İmrol et al. (2021), it is shown that the use of various methods and techniques in the teaching and learning process of the 2018 Turkish curriculum is not at a sufficient level. It is determined that teachers generally use question and answer and narration methods and the development of four basic language skills is not supported in every lesson.

In the 2019 Turkish curriculum fourth grade writing skills learning field, the students have emphasized that “the suggested learning experiences” should include activities such as questions about the text, explaining the text with pictures, finding the topic and main idea of the text, teaching the meaning of words, creating a three-dimensional design for the text, finding a title for the text, summarizing, dramatizing the text, designing a poster with Web 2 tools, completing the unfinished text, rewriting the text in a different text type, spelling and punctuation. Within the scope of the 2019 Turkish curriculum fourth grade writing skills "suggested time", while the majority of the students have stated that more than 30 minutes should be given to writing skills activities, some of the students have stated that less than 30 minutes should be given. Therefore, giving less than 30 minutes for writing activities is insufficient. It is suggested that the time to be given to students for writing activities should be more than 30 minutes. Within the scope of the 2019 Turkish curriculum fourth grade writing skills "suggested material", it is concluded that visual materials, written materials, visual and audio materials, three-dimensional materials, and stationery materials should be used in writing activities. These results of the study are similar to the results of the studies conducted by Barası and Erdamar (2021), Karacaoğlu et al. (2021), Kaplan and Demir (2023). In the study conducted by Barası and Erdamar (2021), teachers have suggested that the activities in the learning and teaching processes of the Turkish curriculum should be associated with daily life, planned and implemented in an interesting way. They have proposed that the physical conditions of the schools should be improved and activities such as drama, discussion, interpretation, and creative writing should be included more in the lessons. In the study conducted by Karacaoğlu et al. (2021), it is shown that written expression materials should be prepared for the "selective writing skills lesson". In the study conducted by Kaplan and Demir (2023), it is identified that the curriculum should be revised in terms of the methods and techniques used in the 2019 Turkish lesson curriculum.

Conclusions Related to the Evaluation Element of the Curriculum

When the curriculum is considered in terms of the "evaluation" element, it is determined that peer assessment is mostly used in the evaluation of the 2019 Turkish curriculum fourth grade writing skills activities, as well as self-assessment, multiple-choice, and verbal exams. It is determined that both traditional and alternative assessment methods are used in the measurement and assessment processes related to writing skills. It is concluded that students generally present their products after writing activities and writing activities are evaluated in terms of topic and content; spelling rules and punctuation; language and expression; and form. These results of the research are similar to the results of the studies conducted by Engin and Arslan (2019), Özdemir and Akkaya (2020), Barası and Erdamar (2021). In the study conducted by Engin and Arslan (2019), it is identified that teachers use techniques such as multiple-choice tests, matching tests, open-ended questions, homework, performance assessment, essay writing, end of the theme assessment, verbal exams, peer assessment and self-assessment. It is found that the most preferred measurement and assessment techniques are written exams, multiple-choice tests, matching tests, open-ended questions and giving homework. In the study conducted by Özdemir and Akkaya (2020), it is stated that within the scope of the 2019 Turkish lesson curriculum, it is aimed to enable students to share their written products in different environments. In the study conducted by Barası and Erdamar (2021), while some of the teachers have stated that measurement and assessment processes should be centralized and objective, some of the teachers have stated that process oriented evaluations should be made more.

In the 2019 Turkish curriculum fourth grade writing skills learning field, the students have emphasized that "the suggested evaluation" should be made with open-ended questions, matching, true-false, self-assessment and peer assessment. This result of the research has emphasized that various methods should be used during assessment. While evaluating writing activities, it is concluded that attention should be paid to punctuation and spelling rules, the way the topic and main idea are given, the beauty of writing, the correct use of words and sentences, the harmony of the text sections with each other, the harmony of the title with the topic, and the spelling of the suffixes. These results of the study are similar to the results of the studies conducted by İmrol et al. (2021), Karacaoğlu et al. (2021), Şimşek (2022), Dilekçi (2022). In the study conducted by İmrol et al. (2021), it is determined that teachers mostly use practices and assessments to measure cognitive skills during assessment. It is emphasized that measurement and assessment methods should be diversified and assessments specific to the four language skills should be made. In the study conducted by Karacaoğlu et al. (2021), it is concluded that evaluation forms, peer assessment and self- assessment forms related to the evaluation of writing skills should be included in every theme in Turkish textbooks. In the study conducted by Şimşek (2022), it is identified that although process oriented evaluation is mentioned in the Turkish curriculum writing skills, written exams are also conducted in line with the objectives. While in the 2018 Writership and Writing Skills curriculum, it is stated that process oriented evaluation is important, in the 2019 Turkish curriculum, measurement and assessment diversity is mentioned. In the study conducted by Dilekçi (2022), teachers have stated that Turkish textbooks should include more and various assessment tools to measure the objectives. In addition, teachers have emphasized that there should be tools that measure skill-based and higher-order skills in the textbooks.

Conclusions Related to the Positive and Negative Aspects of the Curriculum

"The strengths" of the 2019 Turkish curriculum fourth grade writing skills learning field are determined to be that the curriculum allows writing different types of texts, the topics are interesting, it allows text analysis, provides the opportunity to enrich the texts with visuals, teaches new words, and develops imagination. “The weaknesses” of the 2019 Turkish curriculum fourth grade writing skills learning field are determined to be that the writing activities are insufficient, some of the activities are not interesting, there is not enough information about the activities, dictation activities are not liked, different writing methods are not used, there are spelling and punctuation errors, unknown or incomprehensible topics are included, the spaces allocated for writing are insufficient, the writing activities are not related to the unit, there are repetitive explanations, and the evaluation is insufficient. These results of the research are similar to the results of the studies conducted by Mutlu et al. (2019), Oryaşın (2020), Arcagök (2021), Barası and Erdamar (2021), Karacaoğlu et al. (2021), Sulak and Çapanoğlu (2021), Dilekçi (2022). In the study conducted by Mutlu et al. (2019), teachers have stated that secondary school Turkish textbooks are generally not sufficient in terms of measurement and assessment, the questions are insufficient and the evaluation is incompatible with the exam system. In the study conducted by Oryaşın (2020), it is determined that the writing skills activities in the textbooks between the first and eighth grades of the 2019 Turkish curriculum are insufficient to develop students' writing skills. In addition, activities related to the grammar topic field do not attract the attention of the majority of students. The majority of the students have stated that they do not want to answer the questions about the texts and the activities do not reflect daily life. It is concluded that the activities are not suitable for the student level in general. In the study conducted by Arcagök (2021), it is determined that the sixth grade Turkish lesson curriculum cannot meet the interests, wishes, and needs of the students. In the study conducted by Barası and Erdamar (2021), it is determined that teachers experience problems such as the content and length of the texts not being suitable for the age groups of the students, they are not interesting and the text types are not selected from good and quality examples. In addition, teachers have stated that students experience a lack of interest and motivation. In the study conducted by Karacaoğlu et al. (2021), it is suggested that the pages/sections allocated for writing activities should be appropriate for the grade levels of the students and should be long enough to be positively received by the students. In the study conducted by Sulak and Çapanoğlu (2021), teachers have stated that the activities in primary school Turkish textbooks are not sufficient and there should be additional activities. In the study conducted by Dilekçi (2022), it is determined that teachers find the texts in Turkish textbooks long, boring in terms of content, insufficient, and simple. In addition, teachers have stated that the activities in Turkish textbooks are not interesting, and repetitive.

The results of the research can be summarized as follows:

Within the scope of the 2019 Turkish curriculum fourth grade writing skills learning field, although students show improvement in terms of cognitive and psychomotor skills, they experience writing anxiety in terms of affective skills. It is determined that the writing topics in the curriculum are relatively appropriate for the student level. It is also found that the writing activities and the time allocated for writing in the lessons are insufficient. In this respect, it is concluded that practices that are suitable for the developmental level of students and that develop their thinking and writing skills more should be included. It is identified that the tools, methods and techniques used in writing activities are insufficient in terms of diversity. Accordingly, it is concluded that the communication process in the classroom should be more effective during writing activities. Although traditional and alternative assessment methods are used in the measurement and evaluation processes related to writing skills, it is determined that an effective evaluation is not fully carried out.

Within the scope of the results obtained in the research, suggestions can be summarized as follows:

Within the scope of writing skills, objectives to improve students' writing, thinking, research, and communication skills can be added to the curriculum. Curriculum development studies can be carried out to reduce students' writing anxiety and to develop positive attitudes towards writing. Text types, topics and activities included in the curriculum regarding writing skills can be prepared in accordance with students' interests, needs, and developmental levels. An effective communication process can be created in the classroom environment during the activities related to writing skills. Various methods and techniques can be used in activities related to writing skills. Visual and three-dimensional materials suitable for students' interests and needs can be included in the application process for writing skills activities. The time allocated for writing activities can be increased to improve students' writing skills. To improve the quality of writing skills activities, evaluation studies can be done more effectively. By using the evaluation method in this research, the 2019 Turkish curriculum at the fourth grade level can be evaluated as a whole in terms of listening, reading, speaking, and writing learning fields. The 2019 Turkish curriculum fourth grade writing skills learning field can be evaluated by taking opinions from teachers.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

Research involving Human Participants

The research involves human participants. Ethics committee permission was obtained from Balıkesir University Social and Human Sciences Ethics Committee (At the meeting dated 17.03.2022 and numbered 2022/02; Document number: E-20381301-108.02-139199). Since the students participating in the research were at the primary school level, a voluntary consent form was signed by the parents of each student.

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Üstün Zekâlı ve Yetenekli Öğrenciler Açısından Yazma Becerileri Öğrenme Alanının Stake'in İhtiyaca Cevap Verici Değerlendirme Modeline Göre Değerlendirilmesi

Özet:

Bu araştırmanın amacı, üstün zekâlı ve yetenekli öğrenciler açısından 2019 Türkçe dersi öğretim programı yazma becerileri öğrenme alanının değerlendirilmesidir. Araştırmada durum çalışması desenlerinden biri olan bütüncül tek durum deseni kullanılmıştır. Araştırmada amaçlı örnekleme yöntemleri arasında bulunan "ölçüt örnekleme" ve "kolay ulaşılabilir durum örneklemesinden" yararlanılarak çalışma gurubu belirlenmiştir. Araştırmanın örneklemini Ankara ilinin Sincan ilçesindeki dördüncü sınıf düzeyindeki üstün zekâlı ve yetenekli öğrenciler oluşturmaktadır. Araştırma kapsamında gönüllü 21 öğrenci ile görüşme yapılmıştır. Veri toplama aracı olarak araştırmacı tarafından geliştirilen yarı yapılandırılmış görüşme formu kullanılmıştır. Veriler, 2022 yılının Nisan ve Mayıs aylarında toplanmıştır. Verilerin analizinde içerik analizi kullanılmıştır. Araştırmanın güvenirliğinin 0.83 olduğu belirlenmiştir. Araştırma kapsamında öğrencilerin yazma kaygısı yaşadığı, konuların nispeten öğrenci düzeyine uygun olduğu, yöntem ve tekniklerin çeşitliliğinin ve sürenin yetersiz olduğu, değerlendirme sürecinde hem geleneksel hem de alternatif değerlendirme yöntemlerinin kullanıldığı belirlenmiştir.

Anahtar kelimeler: Türkçe dersi öğretim programı, yazma becerisi, Stake'in ihtiyaca cevap verici değerlendirme modeli, üstün zekâlı ve yetenekli öğrenci.

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Research Article

Examples of the Use of Mathematics History in Mathematics Teaching: Ascalon Multiplication Method, Gelosia Multiplication Method and Napier's Rods Method

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Abstract – The aim of this study is to present the Ascalon multiplication method, Gelosia multiplication method and Napier's rods method, which take place in the history of mathematics, to sixth grade students through activities and to determine the effect of these methods on student achievement, and to get student opinions about this activity. The study group of the research consisted of 60 sixth grade students. A worksheet was used as a data collection tool and an interview form was used at the end of the activity to obtain students' opinions about the activity. According to the quantitative analysis results obtained from the research data, it was determined that the methods taught were effective in increasing student achievement. According to the results of the qualitative analysis, it was concluded that students generally did not encounter such activities much, that they learned the lesson by having fun with such activities, and that their interest in mathematics increased.

Key words: History of mathematics, Ascalon multiplication method, Gelosia multiplication method, Napier's rods method

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Introduction

The use of the history of mathematics in mathematics education is a long-standing and supported idea (Barwell, 1913; Fried, 2001; Groza, 1968). Radford and Santi (2022) argue that the history of mathematics in education is a necessity, not a choice, and that it is a central part of the process of understanding human nature in a fundamentally historical and cultural way. In recent years, there has been an increase in domestic and international studies on the use of the history of mathematics in teaching environments and its integration into education (Baki & Bütüner, 2013; Bütüner, 2008; Furinghetti, 1997; Goodwin, 2007; İdikut, 2007; Özdemir & Göktepe, 2015; Siu, 2004; Swetz, 1994). Special issues on the history of mathematics are published in international journals (Jankvist, 2009). In these studies, it is also mentioned that integrating the history of mathematics into mathematics courses has many benefits. In addition, studies in this field, which contribute to research in both mathematics education and the history of mathematics, have also raised important theoretical issues related to mathematics by providing innovative teaching approaches (Chorlay et. al., 2022).

There are many reasons why educators are interested in the history of mathematics. In addition to this, there are many studies in literature on the use of the history of mathematics in mathematics lessons. Fauvel (1991) stated that there are fifteen reasons for being interested in the history of mathematics and that more reasons can be found in literature. Fried (2001) categorized these reasons under three main themes. The first one is that the history of mathematics helps mathematics to be a product of human activity, the second one is that the history of mathematics makes mathematics more interesting, more understandable and more accessible, and the third one is that the history of mathematics provides insight into mathematical concepts, problems and problem solving. Gulikers and Blom (2001) grouped the reasons why it is important to use the history of mathematics into three categories: conceptual discussions, multicultural discussions and motivational discussions. In discussions related to motivation, it has been stated by many studies that working on a problem taken from history will enable students to discover different solutions in addition to modern solutions and that they will have the opportunity to compare these solutions, which will increase their motivation and reduce their anxiety and fear towards mathematics and help them to develop a positive attitude toward mathematics (Fauvel, 1991; Liu, 2003; Swetz, 1997; Tzanakis & Arcavi, 2000). Therefore, including the history of mathematics in mathematics teaching can change students' perspectives on mathematics. By integrating the history of mathematics into mathematics lessons, students will realize that mathematics is a branch of science that can continuously improve itself, that mathematics has a cultural relationship, and how mathematics omit shapes and shapes our ideas (Baki, 2008).

Including the history of mathematics in mathematics lessons allows students to learn how some mathematical expressions and some calculation methods originated, and creates the opportunity to ask questions (Bidwell, 1993; Jankvist, 2009; Tzanakis & Thomaidis, 2000).

Jankvist (2009) stated that the history of mathematics is used in mathematics lessons in two different ways: as a tool and as a purpose. The use as a tool includes arguments about how students learn mathematics. For example, using the history of mathematics in mathematics lessons helps to maintain students' interest and excitement in the subject and is a motivating factor for students to learn and study mathematics (Jankvist, 2009). When used as an objective, the focus is on the developmental and evolutionary aspects of mathematics as a discipline. For example, an objective is to show students that mathematics exists and evolves over time and space and that many different cultures have been influential in shaping mathematics (Barabash and Guberman-Glebov, 2004; Høyrup, 2007; Tzanakis and Thomaidis, 2000;).

Bütüner (2008) taught the eighth grade equations subject by using examples from the history of mathematics. He solved algebraic problems with Ancient Egyptian, Babylonian, Ancient Chinese and Khwarezmi methods and made comparisons with today's solutions. Karakuş (2009) explained the Babylonian method, which is a different approach method for calculating square roots, in detail and gave examples. He provided students with a different experience from traditional square rooting methods in textbooks. Panasuk and Horton (2013) investigated the views of mathematics teachers on teaching by incorporating the history of mathematics, and the teachers stated that the history of mathematics attracted students' interest and mathematical concepts were learned by students with fun. Ersoy and Öksüz (2016) taught the topic of decimal fractions to fourth grade primary school students using the history of mathematics and investigated the effect of teaching on students' achievement, retention level and motivation. According to the results of the study, it was evident that the achievement, retention level and motivation to learn mathematics increased in students who learned decimal fractions using the history of mathematics. Altıntaş and Sidekli (2017) tried to teach multiplication to students studying in unified classes by using Napier's rods and concluded that students' achievement was positively affected. Başıbüyük and Soylu (2019) examined the change in student attitudes by using the history of mathematics in mathematics lessons and applied 15 activities related to the history of mathematics to students. It was concluded that mathematics history practices had a positive effect on students' attitudes towards mathematics course.

In our country, the introduction of the history of mathematics into the textbooks with the elementary mathematics curriculum in 2005 enabled students to make connections between the historical development of mathematics and the historical development of science

(Barry, 2000). In addition, within the framework of the general objectives of the elementary mathematics curriculum, it is emphasized that students should be able to recognize the role of mathematics in the development of historical and human thought and the importance of its use in different fields (Baki & Bütüner, 2013).

For this reason, it is also important to include the use of the history of mathematics in the curriculum. In the study, three multiplication methods, also included in the history of mathematics, were first introduced: " *Ascalon multiplication method*, *Gelosia multiplication method and Napier rods method*".

The Gelosia multiplication method is one of the most popular methods in 15th century algorithms that originated in India. It is believed that the Gelosia multiplication method was transferred westward by Arab traders. For this method it is enough to know multiplication and addition. With the emergence of new calculation techniques such as the Gelosia multiplication method in the early Renaissance, numerical calculation became easier and calculation became faster (Swetz, 1994). However, the rapid development of technology necessitated the search for more efficient tools to perform calculations. When John Napier from Scotland was doing research to facilitate numerical calculations, he found that the numerical entries in the Gelosia columns were almost multiples of the numbers at the beginning of these columns, and Napier transformed the calculation algorithm into a mechanical calculation device. This device, called "Napier's rods" or "Napier's rods", consists of an abacus, a board and a frame. Compared to the abacus, Napier's rods can perform square root operations in addition to multiplication and division.

The National Council of Teachers of Mathematics (NCTM) emphasized the necessity of integrating the history of mathematics into mathematics teaching, that mathematics is a success indicator for the history of humanity and that it is important and necessary to reveal the cultural influences that create this success. In addition, according to NCTM, using the history of mathematics in mathematics teaching will increase student motivation, provide a more positive approach towards mathematics, develop mathematical thinking with the solution of historical problems and guide history learning. From this point of view, it is thought that this study is important in terms of establishing inter-subject and interdisciplinary relationships in mathematics and providing a different perspective by enabling students to learn with fun. The fact that there are few studies in Turkey and abroad in which the history of mathematics is integrated into a teaching environment and activity applications are carried out is one of the other factors that make the study important. The aim of the study is to determine the effect of the Ascalon multiplication method, Gelosia multiplication method and Napier's rods method, which take place in the history of mathematics, on student achievement by presenting them to sixth grade students through activities and to get student opinions about this activity.

Method

A phenomenological design was used for the qualitative part of this study. The purpose of the phenomenological design, one of the qualitative research methods, is to reveal the experiences, beliefs and meanings attributed to a phenomenon (Özmen and Karamustafaoğlu, 2019). Phenomenology is a careful and in-depth description of how participants experience phenomena (Creswell, 2013). The case considered here is the Ascalon multiplication method, Gelosia multiplication method and Napier's rods method, which were invented in history to facilitate numerical calculations. This study is a phenomenological study as it tries to determine students' views on the methods they used in history to facilitate numerical calculations, such as the Ascalon multiplication method, Gelosia multiplication method and Napier's rods method. In the research, a pilot study was conducted for both worksheets, pre-test, post-test and interview questions.

The study introduces the Ascalon multiplication method, Gelosia multiplication method and Napier's rods method, which were found in history to facilitate numerical calculations. The activity sheet (worksheet) prepared for these methods was created by the researchers and the process was carried out by the researchers. Each student answered the activity sheet individually. First of all, multiplication operations were done in normal ways. Then, Ascalon multiplication, Gelosia multiplication and Napier's rods methods were demonstrated with examples and students were asked to solve sample questions related to these methods. After these three methods, the students were asked to perform the normal multiplication operations on the activity sheet again.

The aim here is to compare the multiplication operations that the students first performed with normal methods with the final multiplication operations after different methods and to reveal their effectiveness on student achievement. Since the students' recall was taken into consideration, the numbers in the multiplication operations were chosen from different numbers. After the completion of the examples in the activity sheets, the opinions of fifteen students about this activity were taken.

Participants

The study group of the research consists of 60 sixth grade students studying in a public school in Istanbul. While selecting the student group, the fifth grade mathematics end-of-term averages were examined and the students of the first two grades whose averages were higher than the other grades constituted the sample. The study group was applied to sixth grade students since the activities were related to the subject of operations on natural numbers. Pre-test and post-test were applied to 60 students, and 15 students selected from among the volunteers were interviewed. Necessary permissions and ethics committee approval were obtained before the data collection process. Participation in the study was based on volunteerism.

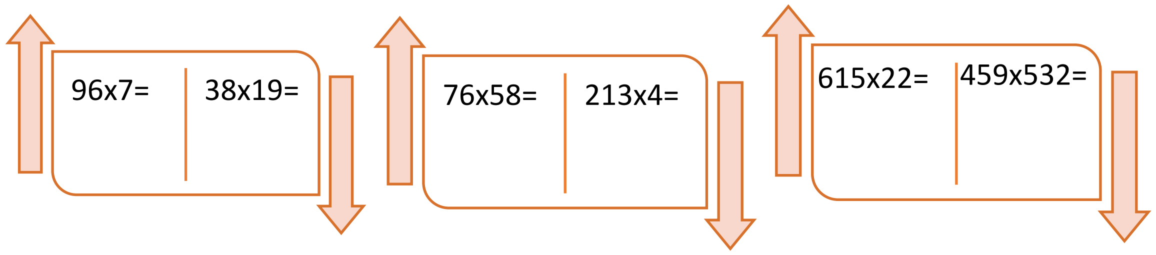
Data collection

The data collection tools of the research are worksheets, interviews, pre-test, post-test and students written documents. (The pre-test and post-test are given in the Appendix A and Appendix B).

Worksheets

Worksheets were prepared by the researchers. While creating the worksheets, Swetz's (1994) book "Learning activities from the History of Mathematics" was used. Multiplication methods in history were taught to sixth grade students by one of the researchers who completed her doctorate in mathematics education. Multiplication operations were given in the first part of the worksheet. In the following parts: Ascalon multiplication method, Gelosia multiplication method and Napier rods method were explained and examples were given to the students. Later, students were asked to give similar examples. In the last part of the study, multiplication operations consisting of different questions are included.

Ascalon Multiplication Method. Question 1 in the worksheet is given in Figure 1.



1. Find the result of the multiplication operations given above.

Figure 1 Worksheet question 1

Ascalon multiplication example is given in Figure 2.

Ascalon Multiplication

Example: To do the 628 x 4 operation with Ascalon multiplication, first the number 628 is decomposed into 600, 20 and 8 digits.

1.Then each of the solved numbers 600, 20 and 8 are multiplied by 4.

$$628 \text{ x } 4 = 600 \text{ x } 4 + 20 \text{ x } 4 + 8 \text{ x } 4$$

$$600 \text{ x } 4 = 2400$$

$$20 \text{ x } 4 = 80$$

$$8 \text{ x } 4 = 32$$

Finally, the result is $2400 + 80 + 32 = 2512$.

Figure 2 Ascalon multiplication example

Questions 2 and 3 on the worksheet are given in Figure 3.

2. Find the result of 84 x 7 using Ascalon multiplication.
3. Find the result of 567 x 9 using Ascalon multiplication.

Figure 3 Worksheet questions 2 and 3

Gelosia Multiplication Method. The Gelosia multiplication method is one of the most popular methods in 15^{th} century algorithms that originated in India. For this method it is enough to know multiplication and addition.

An example of Gelosia multiplication method is given in Figure 4.

Example:

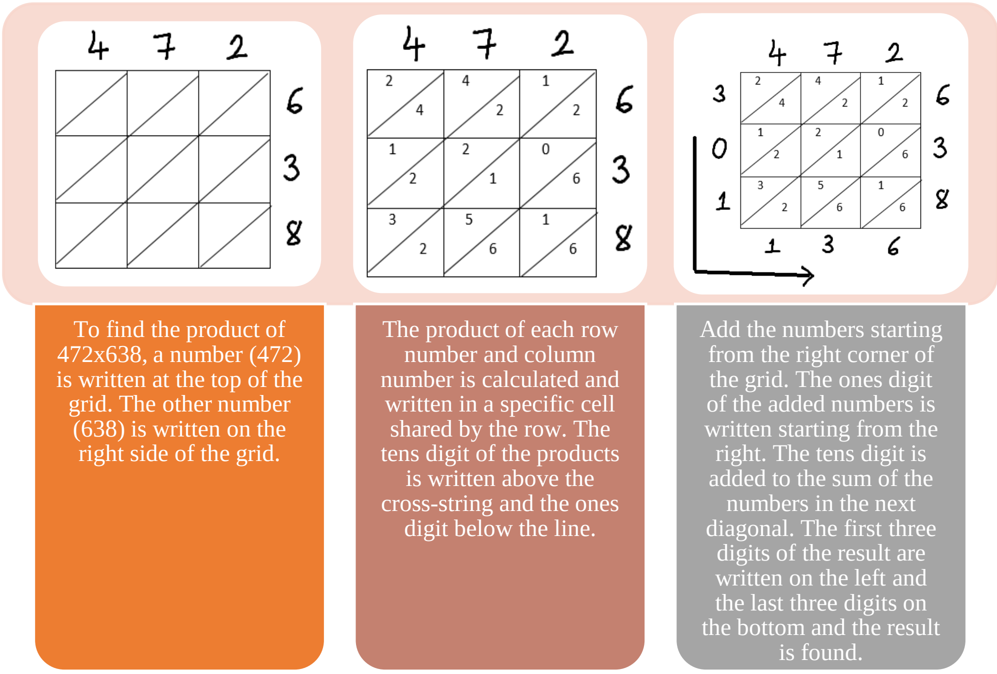
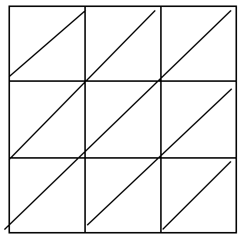


Figure 4 Gelosia multiplication method example

Questions 4 and 5 on the worksheet are given in Figure 5.

4. Find the product of 567 x 249 using Gelosia multiplication method.



5. Find the product of 956 x 956 using the Gelosia multiplication method.

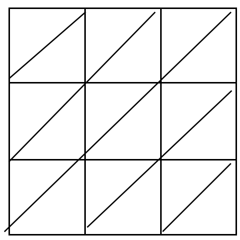


Figure 5 Worksheet questions 4 and 5

Napier's Rods Method. "Napier's rods" or "Napier's rods" is an abacus created by John Napier. Napier's rods can be used for multiplication, division and square rooting in practice (Figure 6).

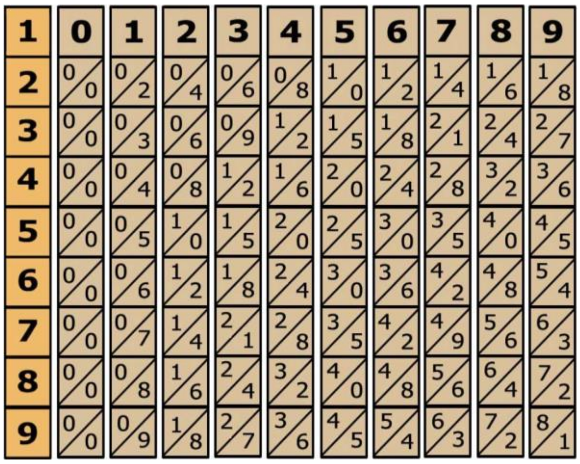


Figure 6 Napier’s rods abacus

An example of the Naiper’s rods method is given in Figure 7.

Example:

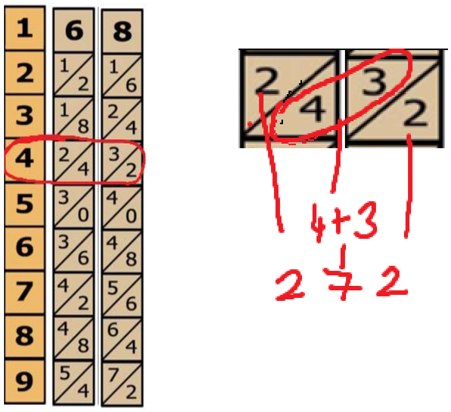
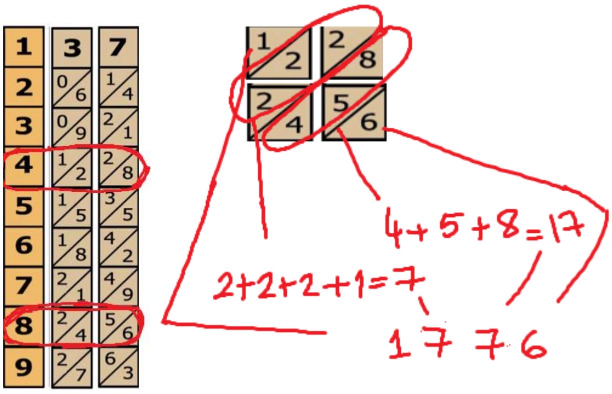
	For the multiplication of 68x4, the boxes corresponding to the numbers 6 in column and 4 in row 8 in Figure 1 are taken. The result of multiplication is found as shown on the side.
	For the multiplication of 37x48, the boxes corresponding to the numbers 3 and 7 in the column and 4 and 8 in the row in Figure 1 are taken. The result of multiplication is found as shown on the side.

Figure 7 Naiper's rods method example

Questions 6, 7 and 8 on the worksheet are given in Figure 8.

6. Find the product of 5 x 92 using Napier's rods method.
7. Find the product of 29 x 56 using Napier's rods method.
8. Find the result of the following multiplication operations.

Figure 8 Worksheet questions 6, 7 and 8

Question 9 on the worksheet are given in Figure 9.

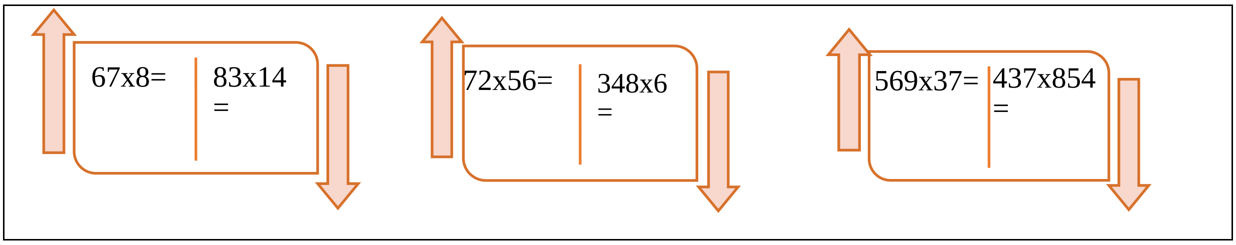


Figure 9 Worksheet question 9

Interview form

Five open-ended questions were prepared by the researchers in order to get the opinions of sixth grade students about the history of mathematics activity they did. 15 students, selected on a voluntary basis, were interviewed. A form containing interview questions was prepared and administered to the students at the end of the activity. The interview lasted around 30 minutes. To ensure the validity of the interview form, the opinions of three experts (two mathematics teachers with 15 years of experience and one mathematics teacher educator) were taken and the questions in the activity were finalized in line with their opinions. The questions in the interview form are given below:

1. Have you ever participated in an activity related to the history of mathematics during your mathematics class? If so, what kind of activity did you take part in?

2. Did you find the activity engaging? What are your opinions about including such activities in your lessons? What alternative activities could be considered?

3. Did you face any challenges while responding to the questions in the activity? If yes, what sorts of difficulties did you experience? Can you provide some examples?

4. Would you be interested in taking mathematics lessons that involve similar activities?

5. Can you establish connections between the topic you learned in the activity and its applicability in everyday life?

Data Analysis

The data obtained from the students' responses to pre-test, post-test, the activity sheet and the interview form were analyzed with qualitative and quantitative analysis methods.

For quantitative analysis, students' pre-test and post-test scores were analyzed and compared with t-test (Büyüköztürk, 2002). The pre-test and post-test scores consist of the first and last questions answered by the students on the activity sheet, which is the data collection tool. Students were given a total of 20 minutes to answer the first and last questions on the activity sheet, 10 minutes for the first question and 10 minutes for the last question. In the pre-test, the students applied the multiplication operations they knew, and in the post-test, after teaching different multiplication operations, most of the students applied the newly learned methods. While preparing the pre-test and post-test questions, the opinions of three experts, two mathematics teachers with 15 years of experience and one mathematics educator, were taken. The questions were finalized in line with the expert opinions.

The answers given by the students in the activity sheets (worksheets) were evaluated according to the rubric prepared by the researchers. The answers given by the students to the activity were categorized as incorrectly answered (zero point), incompletely answered (one point) and correctly answered (two points), and the frequency, total score and student sample answers were given in tables (Table 2, Table 3, Table 4, Table 5, Table 6, Table 7). While scoring the student answers, zero points were given to students who answered incorrectly and left the answers blank, 1 point for each digit in Ascalon multiplication method, 1 point for each multiplication box in Gelosia multiplication method and 1 point for each digit in Napier's rods method.

Content analysis was performed for each interview question asked to the students. Content analysis brings similar data together under specific concepts and themes. It is an organized interpretation of such concepts and themes that help readers to understand better (Yıldırım & Şimşek, 2013). Content analysis is a systematic and renewable technique that summarizes a text's words into smaller content categories with respect to codes based on specific rules (Büyüköztürk, Çakmak, Akgün, Karadeniz, &Demirel, 2009). The findings obtained from the interviews with the students were first transcribed and each interview was recorded electronically as a separate document. Interview data were examined by researchers by content analysis. After the researchers were finished coding the data, the data were compared, and the inter-coder agreement (consistency) percentages were calculated according to the formula specified below. Frequency and percentage tables were created for each interview question. The purpose of content analysis is to organize similar data around certain concepts and themes (Yıldırım & Şimşek, 2013). In content analysis, the data obtained are coded, themes are established with inductive methods as a result of coding, and interpretations are made by organizing the themes. In content analysis, Miles and Huberman's (1994) consensus value was used when determining themes and organizing student responses. The reliability calculation determined by Miles and Huberman (1994) was used to determine the reliability of the study.

$$p = \text{Consensus Percentage} = \frac{N_a \, x \, 100}{N_t}$$

p: Percentage of consistency (compliance)

N_a: Number of students coded in the same way by two researchers

N_t: Total number of students coded by two researchers.

The data collected at the end of the interview were analyzed by coding. When the coding made by two researchers was examined, it was determined that there was a concordance rate of 0.90 (90%) between the coders. Şencan (2005) stated that a consistency percentage of over 80% indicates that coder reliability is achieved. After the determined codes and themes were processed into the program, the characteristics of the resulting data were presented in the findings using tables and graphs.

Findings and Discussions

In this section, findings regarding the pre-test and post-test scores, success scores, percentage and frequency tables of the scores obtained from the interview form regarding the answers of the 60 sixth grade students who participated in the research are included.

Firstly, the Kolmogorov-Smirnov normality test was performed to determine whether the data were normally distributed. Since $p > .05$, parametric tests were used. The results of the analyses of the students' pre-test and post-test scores are given in Table 1.

Table 1 Comparison of students' pre-test and post-test scores by t-test

Score	Groups	N	X	Ss	Sd	t	p
Achievement test	Pre-test	60	4.18	1.51	59	2.96	.004
	Post-test	60	4.71	1.23			

According to Table 1, it is seen that there is a significant difference between the students' pre-test scores obtained from the achievement test before the experimental procedure compared to the post-test scores obtained after the experimental procedure ($p<.05$). While the mean score of the students' answers to the achievement test before the experimental procedure was 4.18, the mean score of their answers to the achievement test after the experimental procedure was 4.71. From this point of view, it can be said that the method applied to the students had an effect on increasing their achievement.

The categories, frequencies, total scores and sample answers of the students' responses to the activity are given below (Table 2, Table 3, Table 4, Table 5, Table 5, Table 6, Table 7).

Table 2 Frequencies, total scores and examples of students' answers to question 2

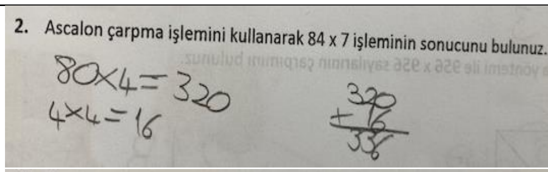
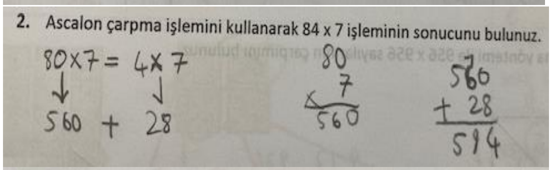
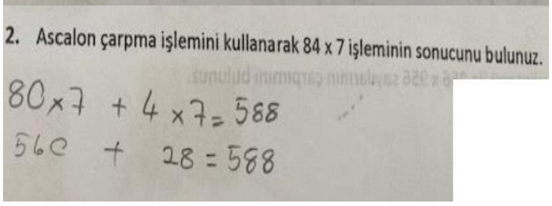
2. Find the result of 84 x 7 using Ascalon multiplication.	f	Total points	Student answers
Incorrect answer	3	0	
Who couldn't fully answer	5	9	
Correct answer	52	156	

Table 2 shows that 52 students answered the Ascalon multiplication correctly. When the student answers are analyzed, it is revealed that the students who could not answer the question correctly usually made mistakes in multiplication. Three students answered the question incorrectly.

Table 3 Frequencies, total scores and examples of students' answers to question 3

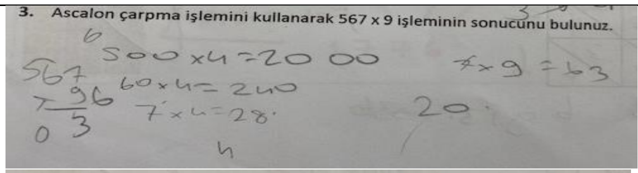
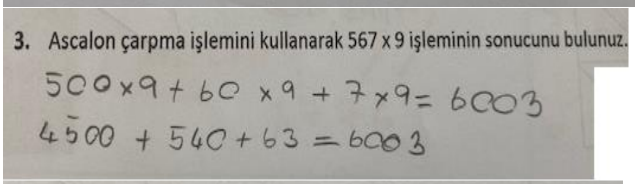
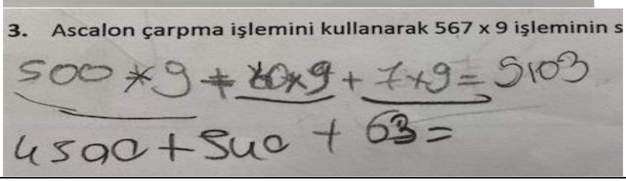
3. Find the result of 567 x 9 using Ascalon multiplication.	f	Total points	Student answers
Incorrect answer	4	0	
Who couldn’t fully answer	10	25	
Correct answer	46	184	

Table 3 shows that 46 students answered the question correctly, 10 students could not find the correct answer and 4 students solved the question incorrectly. The students who could not find the correct answer made mistakes in multiplication and addition.

Table 4 Frequencies, total scores and examples of students' answers to question 4

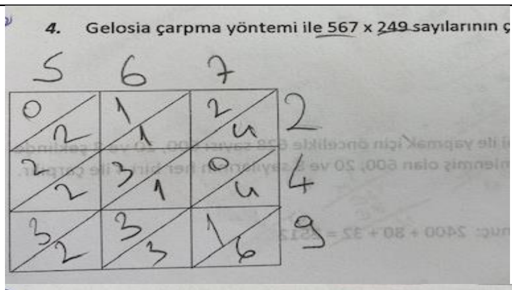
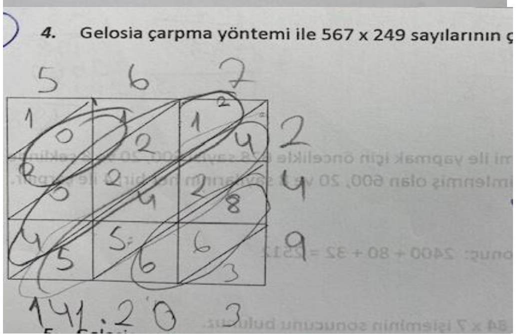
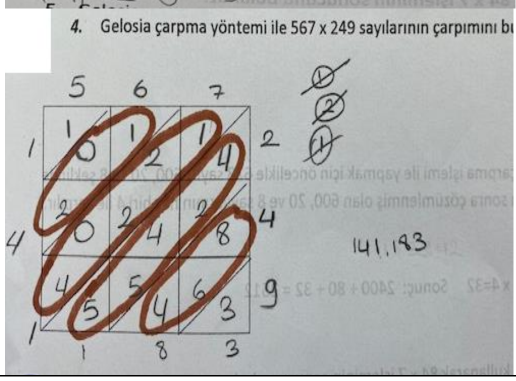
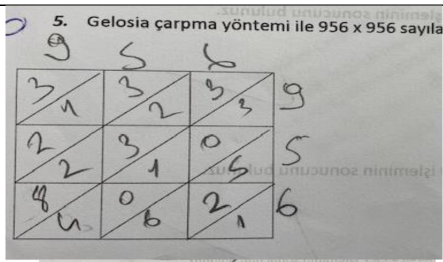
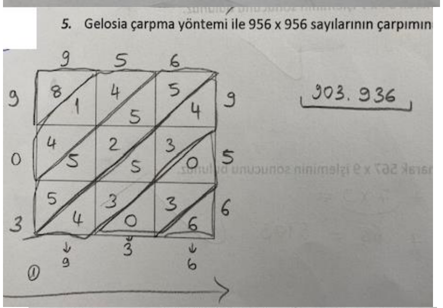
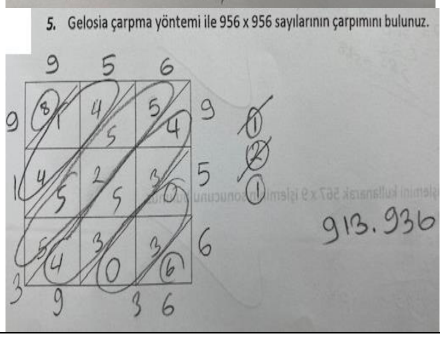
4. Find the product of 567 x 249 using Gelosia multiplication method.	f	Total points	Student answers
Incorrect answer	2	0	
Who couldn't fully answer	14	117	
Correct answer	44	440	

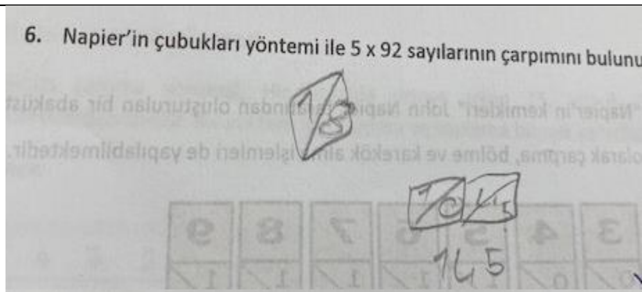
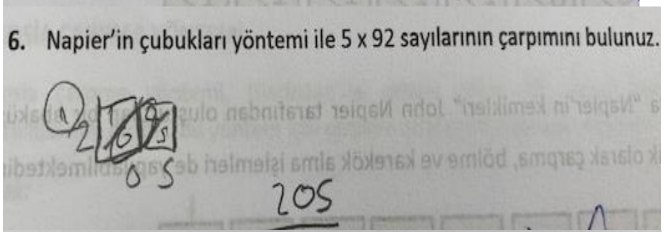
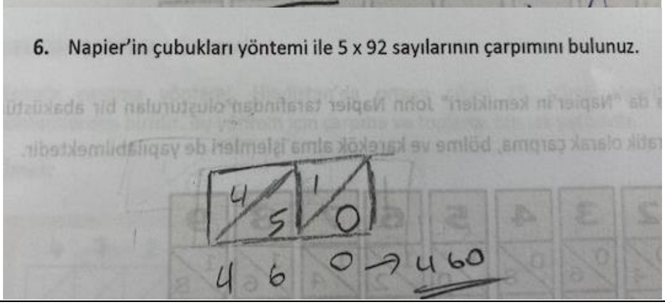
Table 4 shows that the number of students who answered the Gelosia multiplication method incorrectly and left it blank was 2. It can be inferred from this that the majority of the students understood the method. There were 44 students who answered correctly and 14 students who could not reach the correct result due to multiplication and addition errors.

Table 5 Frequencies, total scores and examples of students' answers to question 5

5. Find the product of 956 x 956 using the Gelosia multiplication method.	f	Total points	Student answers
Incorrect answer	5	0	
Who couldn't fully answer	15	107	
Correct answer	40	400	

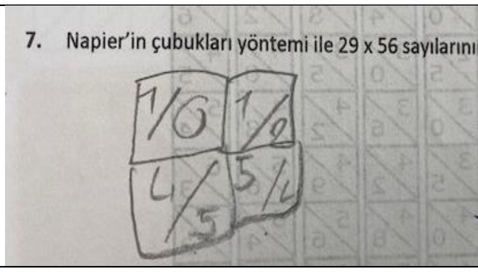
When the students' answers to question 5 are analyzed, it is seen that 40 students answered the question correctly, 15 students could not reach the correct answer due to errors arising from multiplication and addition, and five students left the question blank or answered incorrectly (Table 5).

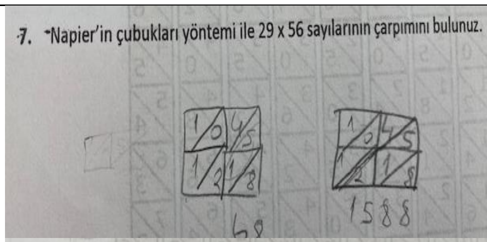
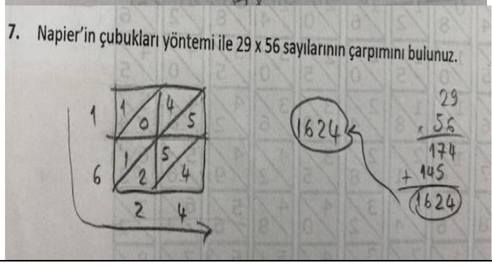
Table 6 Frequencies, total scores and examples of students' answers to question 6

6. Find the product of 5 x 92 using Napier's rods method.	f	Total points	Student answers
Incorrect answer	19	0	
Who couldn't fully answer	4	8	
Correct answer	37	111	

The frequency, total points and sample answers of the students' answers to the multiplication with Napier's rods method are given in Table 6. Nineteen students answered the question blankly or incorrectly because they did not understand the method; 37 students found the correct answer and 4 students could not reach the correct answer.

Table 7 Frequencies, total scores and examples of students' answers to question 7

7. Find the product of 29 x 56 using Napier's rods method.	f	Total points	Student answers
Incorrect answer	19	0	

Who couldn’t fully answer	3	8	
Correct answer	38	190	

The students’ answers to question 7 were similar to their answers to question 6 (Table 7). It is revealed that the number of students who answered correctly was 38, the number of students who could not find the exact answer was 3, and the number of students who answered incorrectly was 19. It is believed that the high number of errors in this method is due to the fact that the students could not find the boxes corresponding to the number values from the abacus.

The percentage and frequency values of the students’ answers to the first question in the interview form are given in Table 8.

Table 8 Percentage and frequency values of the students' answers to the first question in the interview form

Have you ever participated in an activity related to the history of mathematics during your mathematics class?	f	%
Yes	2	13
No	13	87

Thirteen out of 15 students stated that they had not done any activities related to the history of mathematics before. Two of them stated that they had participated in activities related to the history of mathematics, but these activities took place outside the school. They stated that the activities were similar to the multiplication operations in the study and that they learned the old multiplication tables.

In the second question, students were asked whether the activity was interesting or not, what they thought about doing such activities in lessons and what different things could be done. Student responses are given in Table 9.

Table 9 Percentage and frequency values of students' answers to the second question in the interview form

Did you find the activity engaging? What are your opinions about including such activities in your lessons? What alternative activities could be considered?	f	%
Yes	14	93
No	1	7

The percentage of study participants who found the activity interesting was 93%. Some of the student responses about what they think about doing these activities are given below.

Ö1: "Yes, I think it is interesting. I think if activities like these are done in lessons, it will instill in us that mathematics is a fun lesson and help us learn new things."

Ö5: "Yes, it is good to see new methods. It is quite fun. Such activities help us to distract ourselves and help our lessons."

Ö7: "It was interesting, it is good to do such activities. I think such mathematics operations can be taught in mathematics lessons with easy and fun methods."

Ö12: "No, it did not interest me. It should be more illustrated and fun."

In the third question, students were asked whether they had any difficulties in answering the questions in the activity and if they had any difficulties, they were asked to exemplify what kind of difficulties they had. The frequency and percentage values of the students' answers are given in Table 10.

Table 10 Percentage and frequency values of students' answers to the third question in the interview form

Difficulties in answering the activity	f	%
I had no difficulties.	9	60
Multiplication with large numbers	6	40

Sixty percent of the students participating in the study stated that they did not have any difficulty in the activity. Some student responses regarding the difficulties experienced in answering the activity are given below.

Ö2: "I had difficulty in multiplying large numbers while doing normal multiplication operations. The newly taught multiplication operations were easier and more fun."

Ö3: "I had difficulty doing normal multiplication operations with large numbers."

Ö9: "I did not have much difficulty, but it is easier and more logical to use the method with Napier's rods when doing multiplication than other multiplication methods."

As the fourth question, students were asked whether they would like to teach mathematics lessons with such activities. The percentage and frequency values of the answers given by the students are given in Table 11.

Table 11 Percentage and frequency values of students' answers to the fourth question in the interview form

Would you be interested in instructing mathematics lessons that involve similar activities?	f	%
Yes	11	73
No	4	27

In general, 73% of the students who participated in the study stated that they wanted to teach mathematics lessons with such activities and that they enjoyed the activity. 4 students stated that they did not want to teach the lessons with such activities. Some of the answers of the students who want to teach mathematics lessons with such activities and those who do not want to teach mathematics lessons with such activities are given below.

Ö4: "I would like to do mathematics lessons with such activities because it is very nice and fun."

Ö10: "Yes, such activities are very fun. Thus, our interest in the lesson increases even more."

Ö11: "Yes, because we learn in a more memorable way."

Ö13: "Yes, because I had fun and learned at the same time."

Ö15: "No, it is very challenging and difficult to learn."

In the final question, students were asked to associate the subject learned in the activity with daily life. The answers given by the students are given in Table 12.

Table 12 Percentage and frequency values of students' answers to the fifth question in the interview form

Can you establish connections between the topic you learned in the activity and its applicability in everyday life?	f	%
I can make associations	4	27
I cannot make associations	11	73

The students participating in the study were generally (73%) unable to associate the subject learned in the activity with daily life. Some of the answers of the students who were able to make associations with daily life are given below.

Ö6: "I can use some of the methods I learned to make grocery shopping easier in daily life."

Ö8: "I had mathematical knowledge about multiplication operations done in the past, I got to know the past."

Ö14: "I can use these different calculation methods when doing difficult multiplication operations in daily life."

Conclusions and Suggestions

In this study, students were taught different methods in mathematics teaching with examples of activities from the history of mathematics. These methods were found to be effective in student achievement. There are many studies in literature that conclude that using different methods and techniques in mathematics teaching is effective in increasing students' academic achievement (Dereli, 2008; Erdağ, 2011; Çelik, 2013; Altıntaş & Sidekli, 2017).

In the study, activities were carried out with different methods supported by the history of mathematics and students were allowed to see the changing and developing aspect of mathematics. Considering that the history of mathematics has an important place in mathematics teaching, the activities enabled students to see the development of multiplication operations from ancient times to the present day. The achievement test averages of the students before the experimental procedure were found to be lower than the achievement test averages after the experimental procedure. From this point of view, it can be said that the methods taught are effective in increasing student achievement. Altıntaş and Sidekli (2017) found that the use of Napier rods in teaching multiplication positively affected students' academic achievement, which supports the results of the study. Yuriana and Suwardi (2019) examined the development of students' achievement in multiplication in mathematics lessons using Napier's rods teaching method and concluded that the teaching method increased students' achievement in mathematics. This result is in parallel with the findings of this study. Similarly, İdilkut (2007) concluded that conducting activities from the history of mathematics in lessons positively affected students' academic performance.

It was observed that the students generally answered the questions of Ascalon multiplication method and Gelosia multiplication method correctly, but the answers that they could not answer correctly were due to multiplication and addition errors. In the Napier's rods method, students had difficulty in finding the corresponding boxes on the abacus and therefore their incorrect answers were higher than their incorrect answers in other methods.

The answers to the interview questions revealed that the students had not encountered such activities in their mathematics lessons before. When the studies in the literature are examined, it is supported by this result that teachers continue the activities they have seen from their own teachers and do not include different activities (Furinghetti, 2000). In addition, Ceylan (2021) examined the use of the history of mathematics in secondary school mathematics textbooks and concluded that the history of mathematics is not sufficiently utilized in secondary school mathematics textbooks. It is important to include such activities in order to ensure students' active participation in the lesson and to help them have a positive attitude towards mathematics.

When asked whether they found the activity questions interesting or not, 93% of the students stated that they found them interesting, that they learned new things with such activities, that teaching mathematics with easy and fun methods increased their motivation and that they approached mathematics lessons more positively. Liu (2003) stated that students' developing positive attitudes towards mathematics is one of the purposes of including the history of mathematics in mathematics lessons. Similarly, Panasuk and Horton (2013) found that students had fun while engaging in such activities, which is in line with the result of the study.

In the opinions of the students participating in the study regarding the difficulties in answering the activity, it was determined that they had difficulty in multiplication with large numbers. Students stated that the methods taught were more fun and that they made calculations more easily than long multiplication operations.

Seventy-three percent (73%) of the students stated that they would like to teach mathematics lessons with such activities. Students stated that they experienced more memorable learning with such activities, that they learned by having fun and that their interest in mathematics lessons increased even more in this way. Özdemir and Yıldız (2015) examined student views on the use of the Babylonian counting system activity example in mathematics lessons and concluded that most of the students wanted to do an activity from the history of mathematics in their mathematics lessons. This result coincides with the study.

In his study with pre-service mathematics teachers, Clark (2012) stated that a relationship can be established between algebraic representation and geometric representation through the history of mathematics. Similarly, Baki and Bütüner (2013) made suggestions about the ways of using the history of mathematics in mathematics courses. These studies can be increased and such mathematics history activities that can attract students' interest can be included more in teaching environments.

Seventy-three percent (73%) of the students who participated in the study could not associate the subject learned in the activity with daily life. The students who were able to make an association were evaluated with the dimension of making calculations. This question was included because associating mathematics topics with daily life is considered very important. Because students who can make associations with daily life learn mathematical concepts in a more meaningful way and learn to perceive abstract mathematics as real by making it concrete.

In general, according to the results of the study, it is seen that Ascalon multiplication, Gelosia multiplication and Napier's rods methods are effective in increasing students' achievement and the use of such activities in teaching environments contributes to the development of positive attitudes towards mathematics courses. When the literature was examined, it was discovered that there were few studies in which the history of mathematics was used in lessons. Such studies can be increased, and in-service training can be given to pre-service teachers on how to use activities in lessons. Studies can be conducted with different study groups using different methods.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

The authors declare no conflict of interest. The research is a study involving human participants. Therefore, data were collected after the participants approved the written informed consent form.

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Research involving Human Participants and/or Animals

Prior to commencing the research, permission was obtained from the ethical committee of Biruni University under the number 2023/82-12, and it has been confirmed that there will be no ethical issues.

Matematik Öğretiminde Matematik Tarihi Kullanımına Örnekler: Ascalon Çarpma Yöntemi, Gelosia Çarpma Yöntemi ve Napier'in Çubukları Yöntemi

Özet:

Bu çalışmanın amacı, matematik tarihinde yer alan Ascalon çarpma yöntemini, Gelosia çarpma yöntemini ve Napier'in çubukları yöntemini etkinlikler yolu ile altıncı sınıf öğrencilerine sunmak ve bu yöntemlerin öğrenci başarısına etkisini belirleyerek bu etkinlik hakkında öğrenci görüşlerini almaktır. Araştırmanın çalışma grubunu 60 altıncı sınıf öğrencisi oluşturmuştur. Veri toplama aracı olarak çalışma yaprağı ve etkinlik bitiminde öğrencilerin etkinlik hakkındaki görüşlerini almak için görüşme formu kullanılmıştır. Öğrencilerin etkinlik kağıdına ve görüşme formuna verdiği cevaplar doğrultusunda elde edilen veriler nitel ve nicel analiz yöntemi ile analiz edilmiştir. Araştırma verilerinden elde edilen nicel analiz sonuçlarına göre kullanılan yöntemlerin öğrenci başarısını arttırmada etkili olduğu belirlenmiştir. Nitel analiz sonuçlarına göre ise genel olarak öğrencilerin bu tür etkinlikler ile fazla karşılaşmadığı, bu tür etkinlikler ile eğlenerek dersi öğrendikleri ve matematik dersine karşı ilgilerinin arttığı sonucuna ulaşılmıştır.

Anahtar kelimeler: Matematik tarihi, Ascalon çarpma yöntemi, Gelosia çarpma yöntemi, Napier'in çubukları yöntemi

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Appendix A

Pre Test
Do the following multiplication operations
96 x 7 = ?
38 x 19 = ?
76 x 58 = ?
213 x 4 = ?
615 x 22 = ?
459 x 532 = ?

Appendix B

Post Test
Do the following multiplication operations
67 x 8 = ?
83 x 14 = ?
72 x 56 = ?
348 x 6 = ?
569 x 37 = ?
437 x 854 = ?

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Research Article

Effect of Concept Cartoons on Students' Achievement, Speaking Skill, and Motivation in English Teaching

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Abstract – Although many different methods of teaching English have been tried, the problem of learning it continues. Concept cartoons that allow dialogic conversation in teaching English will contribute to solving this problem. This study examines the effect of concept cartoons in the sixth-grade English course unit "Yummy Breakfast" on students' achievement, speaking skills, and motivation. The non-equivalent pre-test post-test control group design was adopted in the study. There were 33 sixth-grade students, 18 in the experimental group and 15 in the control group. While the experimental group received English curriculum instruction supplemented by concept cartoons, the control group received instruction in the English curriculum. The study lasted 24 hours, including two hours of pre-testing, 18 hours of treatment, and four hours of post-testing. The results demonstrated that using concept cartoons in the classroom improved students' speaking ability and motivation. However, there was not any significant difference between students' achievement scores.

Key words: English concept cartoons, English language teaching, academic achievement, speaking skill, motivation

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Introduction

In Turkey, a generation who does not speak English enough to communicate, cannot understand what is said, cannot convey their thoughts, or cannot understand written texts only by translating them into Turkish has been raised (Paker, 2012). Although it is accepted that knowing English is indispensable in today's conditions and important steps have been taken on this subject, considering the period from the beginning of education until graduation from the university, it is seen that the English learned is not at the desired level (Çelebi, 2006). There are exams at the international level containing information on the level of English proficiency in Turkey. According to the 2020 report of the English First English Proficiency Index assessing countries' English language proficiency level, Turkey ranks 79 among 100 countries (EF Education First, 2020). Based on this information, we can conclude that English learning is an issue in Turkey.

In the studies conducted on the subject, it is emphasized that this situation may be caused by many factors such as the foreign language teacher training system, teaching material, lack of motivation, constant change in teaching methods, and anxiety (Suna & Çelebi, 2013). In addition, it is emphasized that this fact might depend on the teaching of English based only on grammatical structures, and English is perceived as a problem with formulas just like in mathematics (Paker, 2012). Thus, Kolb and Raith (2018) suggest that a learning environment where students can speak a foreign language and interact with others should be provided. Additionally, it is seen that different methods have been used such as drama activities (İkinci, 2019), literature groups (Kökler, 2019), flipped learning (Koçak, 2019), layered curriculum (Ilıman, 2018), puppet model (Çay, 2017), cooperative learning (Kartal, 2014). However, some methods have not been tried in English language teaching. One of them is the concept cartoons.

Concept cartoons are cartoons in which different characters express their thoughts relating to a context and do not aim to make you laugh (Yurtyapan et al., 2017). Furthermore, concept cartoons based on student interactions provide students with a classroom setting in which they can engage in a reciprocal discussion (Naylor & Keogh, 2013). Thanks to the concept cartoons, students reconstruct their understanding and are directed to think differently (Chin & Teou, 2009). The integration of expressions containing very little text with a visual in concept cartoons makes it relatively easy for students to interact in a language that is not their mother tongue. In addition, simple presentation of concepts with concept cartoons and their compatibility with daily life help students develop their language skills by creating a starting point for language learning (Naylor & Keogh, 2013). Since the teacher does not convey the information and it is possible to create a discussion environment in which all students can participate, students are encouraged to participate in the course willingly (Webb, 2015). Thus, students who do not talk much in lessons can express their ideas more easily (Keogh & Naylor, 1996).

Besides contributing to learning, it has been observed that concept cartoons have an increasing effect on students' motivation (Chin & Teou, 2010; Keogh et al., 1998). Concept cartoons that make lessons fun and interesting, play the role of saving students from a boring lesson (Birişçi et al., 2010). Furthermore, students with high motivation can communicate more easily in a foreign language (Paker, 2012). Expressing motivation as the hormone of foreign language teaching, İşigüzel (2011) underlined that even if the best teaching method and material are used in the classroom, foreign language teaching may be insufficient if motivation is lacking. Foreign language, achievement, and motivation in a foreign language are compared to intertwined rings. 45 years of studies on the relationship between foreign language achievement and motivation have shown that a person with a strong desire to study a foreign language will obtain high levels of proficiency in that language (Gardner, 2006).

However, in the relevant literature, it is generally indicated that concept cartoons have been used in science teaching, not in English teaching, except for a study in which the concept cartoon method was used for teaching English idioms in determining the effect of different learning environments (Gümüş, 2017). On the other hand, concept cartoons have been used to increase student achievement (Estacio, 2015; Karaca, 2019; Şenocak, 2018), motivation (Chin & Teou, 2010; Fenske et al., 2011; Kusumaningrum et al., 2018) and classroom communication (Chin & Teou, 2009; Morris et al., 2007; Sexton et al., 2009) in the teaching of different courses. Hence, it becomes evident that concept cartoons, a method that will enhance both achievement and motivation, should be investigated by using them in English language teaching.

Concept Cartoons

Brenda Keogh and Stuart Naylor originally developed concept cartoons in 1991 to be used in science courses and the education of the teachers of these courses (Naylor & Keogh, 2013). Concept cartoons are images prepared in cartoon format in which a conversation about a special concept between characters is represented (Keogh & Naylor, 2000). The use of the word "cartoon" can be misleading as it suggests a relationship between concept cartoons and humor because concept cartoons aim to make you think, not laugh or satire (Keogh & Naylor, 1999; Keogh et al., 1998). For this reason, exaggerated elements are not included in concept cartoons; however, they show the feature of cartoons because they are created in the form of drawings (Çelikkaya, 2018). Thus, concept cartoons which are based on the visual representation of a special concept belonging to the science course with a text in the form of a dialogue are designed to make students think about concepts (Keogh & Naylor, 1996). Besides, concept cartoons which are innovative teaching and learning strategies are original and stimulating material that reveals learners' views and helps them (Naylor & Keogh, 1999a).

In concept cartoons, a group of three, four, or five characters is depicted for a concept that they make different explanations about a situation that can be encountered in daily life (Stephenson & Warwick, 2002). The dialogue-style conversation of these characters is the turning point in the creation of concept cartoons (İngeç, 2008). At the same time, the alternative perspectives produced by the characters are of equal value and stimulus that encourages students to think scientifically (Morris et al., 2007). Thus, this situation contributes to classroom interaction (Naylor et al., 2007).

In concept cartoons, students are not expected to find the correct answer, as in multiple-choice tests. In line with the alternative ideas of cartoon characters, it is aimed to be part of a teaching process where students can put forward and discuss their ideas (Atasoy, 2017). Apart from this, it is a process that involves students interpreting the thoughts behind the alternative view they choose, questioning their own choices by listening to their friends who suggest different opinions, and establishing a connection between the context in the concept cartoon and what they experience in daily life (Skamp & Preston, 2015). Dabell (2008) compares concept cartoons to a swimming pool. He states that in this pool, some students may dive to the bottom, some students may swim, and others will be afraid to enter the pool. He also emphasizes that the teachers must control the ideas that the students splash around in the pool and help them fluctuate in their thoughts. Consequently, there is no strict rule to be followed when creating concept cartoons (Dabell, 2008), but there are some basic features that should be included in concept cartoons (Keogh et al., 1998; Naylor & Keogh, 1999b; Naylor & Keogh, 2013):

• They contain alternative ideas that make the concept appear to be problematic in context. The reason for this is to display different opinions about the situation. In this way, the quality of the interaction is increased by making it easier for learners to participate in the discussion environment.

• They are all prepared equally so that all alternative ideas are considered and evaluated. There is also more than one acceptable alternative idea. In this way, learners cannot find out which alternative ideas are correct, and successful students are presented with an additional level of difficulty.

• They contain a minimal amount of text so that they can be understood by some limited literate learners. Thus, they are easily understood by learners of all ages. Complex concepts and technical terms are presented to the learner by simplifying them.

• The facial expressions of the characters should not point to the answer.

• Care is taken not to link alternative ideas with the gender, age, and cultural background of the characters. The contextual hint needs to be minimized.

• Situations in which events in daily life are integrated into scientific concepts are used. It is ensured that students make connections between science and daily life. It can be used successfully in different countries regardless of specific geographic and cultural boundaries.

• It can be presented to different age groups in different ways depending on the suitability of the subject.

• Alternative ideas are voiced by cartoon characters. This situation makes it easier for students with low self-confidence to express themselves. In this way, if the chosen opinion is not correct, they can state that it is the character's fault, and they will not receive negative feedback.

In this context, while selecting a subject, paying attention to the selection of a subject that allows the preparation of English concept cartoons and includes the expressions frequently used in daily life was significant. Moreover, the sentence patterns that could be used in the form of a dialogue on the chosen topic should be included and this should allow it to be presented in cartoon format. Since it was thought that these conditions could be provided in the sixth-grade "Yummy Breakfast" unit most appropriately, concept cartoons were used in the teaching of this unit.

Significance and Aim

When the literature was examined on concept cartoons used in teaching English or any other language, it was found that past research has generally examined the effect of using concept cartoons in science, but not in teaching English. This study aims to examine the potential effect of concept cartoons on students' achievement, speaking skills, and motivation in the "Yummy Breakfast" unit in the sixth-grade English curriculum. Following this main purpose, the following research questions were formulated:

1. Is there a significant difference in the English Achievement Test post-test scores for experimental and control groups when pre-test scores on this test are controlled?

2. Is there a significant difference in the English Motivation Scale post-test scores for experimental and control groups when pre-test scores on this scale are controlled?
3. Is there a significant difference in the English Speaking Rubrics post-test scores for experimental and control groups?

Method

Research Design

In this study, the non-equivalent control group quasi-experimental design was adopted. When a cause-and-effect connection between dependent and independent variables is required, experimental research is utilized (Creswell, 2012). It has been tested whether the independent variable of the research (teaching supported with concept cartoons) has any effect on dependent variables (achievement, speaking skills, and motivation). While the students in the experimental group were taught the English curriculum with the support of concept cartoons, the teaching recommended by the English curriculum was carried out with the control group students. The research was carried out in a total of 24 lesson hours, including 2 lesson hours for pre-test implementation of the "English Achievement Test" and "English Motivation Scale", 18 lesson hours (6 weeks, 3 lessons per week) for treatment, and 4 lesson hours for post-test implementation of "English Achievement Test", "English Motivation Scale" and "English Speaking Skill Rubrics". The symbolic representation of the research design is demonstrated in Table 1.

Table 1 The Symbolic Representation of The Research Design

Groups	Pre-test (2 Lesson hours)	Treatment (18 Lesson hours)	Post-test (4 Lesson hours)
Experimental Group	English Achievement Test English Motivation Scale	Teaching supported by the concept cartoons in the English curriculum	English Achievement Test English Motivation Scale English Speaking Skill Rubrics
Control Group	English Achievement Test English Motivation Scale	Teaching in the English curriculum	English Achievement Test English Motivation Scale English Speaking Skill Rubrics

Participants

The research participants consisted of 33 sixth-grade students at a public secondary school in Turkey in the fall semester of the 2019-2020 academic year. Two of the sixth-grade classes were randomly assigned to experimental and control groups. There were 18 students in the experimental group and 15 students in the control group.

Data Collection Tools

English Achievement Test

This study used the English Achievement Test developed by the researchers to check whether the reading and listening learning outcomes of the “Yummy Breakfast” unit were achieved. The test served both as the pre-test and post-test. Firstly, the table of specifications showing the level of the cognitive domain of the reading and listening learning outcomes was prepared. An item pool that consisted of 40 reading questions and 20 listening questions was created. The achievement test was administered to 199 sixth-grade pupils to conduct a validity and reliability study. For each item in the trial form, the item discrimination index and item difficulty index were determined. Taking into consideration the indexes of the test items, 30 items, 20 in the reading section and 10 in the listening section were selected for the achievement test. After the selection of the items for the final test was completed, the reliability coefficient of the test was calculated. In the calculation of the reliability coefficient, the Kuder-Richardson formula (KR-20) was used. The KR-20 reliability coefficient of 20 items prepared for reading outcomes was .91 while 10 items for listening outcome was .82. The KR-20 reliability coefficient of 30 items was 0.92.

English Speaking Skill Rubrics

This study used two English Speaking Rubrics which were developed by the researchers to check whether two speaking learning outcomes were achieved. The rubrics were used as the post-test. Rubrics were applied only as a post-test because they were prepared as holistic. Firstly, the table of specifications showing the level of the cognitive domain of the speaking learning outcomes was prepared. To determine the performance of the students, it is necessary to determine which tasks they will perform and the evaluation criteria (Atılgan et al., 2018). In this context, two separate rubrics were prepared for two learning outcomes. The rubric includes “grammar, vocabulary, fluency and pronunciation, communication” titles. The criteria are rated from 0 to 4 for each title. The total point is 20. The sum of the scores obtained from the two rubrics shows the final score of the students. The content validity of the English-Speaking Skill Rubrics was provided by the opinions of two faculty members in the field of measurement and evaluation in education at the university.

English Motivation Scale

The English Motivation Scale translated into Turkish by Yılmaz (2007) was used to measure the students' motivation levels for the English course. The scale served as the pre-test and post-test. The scale was prepared by using the items in the Attitude Motivation Test Pool which was originally developed by Gardner (1985) to determine the motivation levels of 7th-11th grade French learners in Canada. The adapted scale consists of two parts. In the first part, there are questions regarding the demographic information of the students. In the second part of the scale, 44 items try to determine the level of motivation and motivation type. The items are prepared in a 5-point Likert type. Items (1-14) of the scale measuring the students' motivation level were used in the study. The alpha coefficient was calculated as 0.87 because of the scale's pilot application.

Experimental Process

Firstly, research permission was obtained from Balıkesir Provincial Directorate of National Education on 09/09/2019 before the data collection tools were developed and before the implementation was carried out. Then, lesson plans including concept cartoon activities were prepared for the learning outcomes of the "Yummy Breakfast" unit in the sixth-grade English curriculum. 18 concept cartoons were prepared by using the cartoon preparation program called "Toondoo" for the words and sentence patterns determined in line with outcomes (Table 2). A sample of concept cartoons was presented in Appendix 1. Before the treatment, the English Achievement Test and English Motivation Scale were administered to the experimental and control group students as pre-tests.

Table 2 Outcomes and Concept Cartoons by Weeks

Learning Outcomes	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week	Total
Listening E6.2.L1. Students will be able to identify the names of different food in an oral text.	2			12	14	18	4
Spoken Interaction E6.2.SI1. Students will be able to ask people about their food preferences.	1	6		10	13		4
Spoken Production E6.2.SP1. Students will be able to express their opinions about the food they like and don't like.		4	8	11		16	4
Reading 1 E6.2.R1. Students will be able to understand short and simple texts about food and preferences.	3	5				17	3
Reading 2 E6.2.R2. Students will be able to understand the label of food products.			7 9		15		3
Total	3	3	3	3	3	3	18

In the treatment, the students were informed about the usage of concept cartoons in the unit and what was expected from them in the process. The experimental group received English curriculum instruction supported by concept cartoons, while the control group received instruction in the English curriculum. Concept cartoons were presented by projecting on the smart board. First, the students were asked to examine the concept cartoon. Then, the students explained which of the cartoon characters' views they agreed with, along with the reason. At this stage, all students who wanted to express their opinions were given the right to speak. Students were provided to express their ideas freely. Since no right or wrong feedback was given by the teacher, the students developed different perspectives towards the context. Finally, at the end of the classroom discussion, a decision was made with the teacher about alternative opinions that might or might not be true.

After the treatment, the English Achievement Test, English Speaking Skill Rubrics, and English Motivation Scale were applied to the experimental and control group students as post-tests. Speaking exams for rubrics were held on different days. Before the exam, rubrics for each student were prepared as a printout. Students were taken to the exam one by one. The exam duration was limited to 5 minutes. Before starting the exam, the students were told what was expected of them. For Rubric 1, students were given a menu with food and drinks. It was stated that they would speak with their teacher and ask appropriate questions for the answers by using this menu. For Rubric 2, students were shown a table with 12 food and beverage visuals. It was explained that they were expected to make sentences about the foods and drinks they liked and disliked by using the visuals in this table. During the exam, the statements made by the students were carefully listened to, and after the student completed the exam, the statements made by the students were written on the printout and confirmed to the students. After the student left, the student was awarded points. After completing the exam of all students, it was checked whether the correct score had been awarded by comparing the statements and scores of the students. After the exams were completed, the student’s scores from two scoring keys were added and their speaking skills post-test scores were reckoned.

Data Analysis

In the study, firstly, the achievement and motivation pre-test scores of the groups were compared with independent samples t-test to determine whether the groups were equal. No significant difference was found between the pre-tests’ mean scores between experimental and control. As shown in Table 3, experimental and control groups are equivalent to each other in terms of the English Achievement Test and English Motivation Scale pre-test scores.

Table 3 T Test Results of Pre-Test Achievement and Motivation Scores Between the Experimental and Control Groups

Pre-tests	Groups	N	$\bar{X}$	S_x	Levene Test		df	t	p
					F	p			
English Achievement Test	Experimental	18	10.00	4.18	3.21	.083	31	-.982	.333
	Control	15	8.80	2.39					
English Motivation Scale	Experimental	18	3.83	.71	.79	.379	31	.796	.432
	Control	15	4.01	.52					

After the treatment was completed, achievement, speaking skill, and motivation post-test scores of the groups were compared to find out whether there was a significant difference between the groups. Before the analyses, it was examined whether the data were distributed normally. Skewness and kurtosis values of the data were checked to examine the normality. For the first and second research questions, analysis of covariance (ANCOVA) was used to compare the achievement and motivation post-test scores of the groups by assigning the achievement and motivation pre-test scores as covariates. The analysis assumptions, reliability of covariates, linearity, homogeneity of regression slopes, and homogeneity of variance were checked before the analysis. For the third research question, an independent samples t-test was used to compare the speaking skill post-test scores of the groups. Cohen's d statistic was used to calculate the effect size.

Findings

The results were organized into three research questions.

Research Question 1

To examine the effectiveness of two distinct interventions on students' achievement, a one-way between-groups analysis of covariance was conducted. The independent variable served as the type of intervention (teaching supported by the concept of cartoons in the English curriculum/teaching in the English curriculum), and the dependent variable consisted of achievement test post-test scores. Participants' achievement test pre-test scores were used as the covariate in this analysis. After adjusting for achievement pre-test scores, achievement test post-test scores were significantly different between the two intervention groups, $F(1, 30)=3.90$, $p>.05$, partial eta squared=.115 (see Table 4). There was a significant difference between the achievement test pre-test and post-test scores, $F(1, 30)=7.71$, $p<.05$, partial eta squared=.204.

Table 4 ANCOVA Results of the English Achievement Test

Source	Type III Sum of Squares	df	MS	F	p	Partial Eta Squared
Pre-test	269.26	1	269.26	7.71	.009	.204
Group	136.21	1	136.21	3.90	.058	.115
Error	1047.44	30	34.91			
Total	10568.00	33				

Research Question 2

A one-way between-groups analysis of covariance was used to assess the impact of two different treatments on students' motivation. The independent variable served as the type of intervention (teaching supported by the concept cartoons/ teaching in the English curriculum), and the dependent variable consisted of motivation scale post-test scores. Participants' motivation scale pre-test scores were put to use as the covariate in this analysis. After adjusting for motivation pre-test scores, motivation scale post-test scores were significantly different between the two intervention groups, $F(1, 30)=52.17$, $p<.05$, partial eta squared=.635 (see Table 5). The motivation scale pre-test and post-test scores were significantly different, $F(1, 30)=9.71$, $p<.05$, partial eta squared=.245.

Table 5 ANCOVA Results of the English Motivation Scale

Source	Type III Sum of Squares	df	MS	F	p	Partial Eta Squared
Pre-test	1.382	1	1.382	9.716	.004*	.245
Group	7.419	1	7.419	52.176	.000*	.635
Error	4.266	30	.142			
Total	632.607	33				

Research Question 3

An independent-samples t-test was used to compare the impact of two different interventions on students' speaking skills post-test results. Table 6 presents the results of the analysis.

Table 6 Independent T Test Results of the English-Speaking Rubrics

Groups	N	M	SD	df	t	p
Experimental	18	32.61	2.68	31	-4.562	.000
Control	15	21.26	9.31			

There was a significant difference in scores for the experimental group (M=32.61, SD=2.68) and control group (M=21.26, SD=9.31; t(31)=-4.562, p=.000, two-tailed). Cohen's d effect size statistic was used to compare experimental and control groups. The magnitude of the differences in the means (mean difference=-10.78, 95% CI: -16.28 to -5.28) was large (eta squared=1.47).

Conclusions and Suggestions

It is discussed in the literature that even though English has been taught in Turkey for years, there is a problem of not getting the desired result (Çelebi, 2006; Paker, 2012). Therefore, this is the first study using concept cartoons which is a method believed to help in overcome this problem in teaching English. This study investigated the effect of concept cartoons on students' achievement, speaking skills, and motivation in English language teaching. We highlight five results from the current study that could have significant consequences for concept cartoons in English language teaching.

First, we used achievement test pre-test scores as a covariate, and then the result revealed that teaching supported by the concept cartoons did not make any difference in terms of achievement test post-test scores. We may attribute this result to the teaching that both groups received. Consequently, two different teaching improved the achievement, but the experimental group had higher scores than the control group. This finding is also supported by the empirical findings (Gümüş, 2017; Sayın, 2015; Yurtyapan, 2018) that concept cartoons promoted students' achievement although there was no significant difference. However, some research (e.g., Akkaya, 2011; Ayhan, 2017; Balcı, 2018; Estacio, 2015; Karaca, 2019) revealed a statistically significant difference in students' achievement.

Second, we used motivation scale pre-test scores as a covariate, then we obtained that experimental group students' motivation increased throughout the intervention. The increase in the scores of the experimental group demonstrated that this was caused by teaching supported by the concept cartoons. Previous research (İnel, 2012; Meriç, 2014; Sayın, 2015) on concept cartoons and their effect on motivation shows results in line with our study. Keogh et al. (1998) emphasized that they observed from the first stage of the lesson was motivation while applying concept cartoons in their lessons. They stated that when teachers teach with concept cartoons, students are more motivated, and even those who have behavioral disorders and are unwilling, they make positive comments about the lesson. Kusumaningrum et al. (2018) conclude that the use of concept cartoons motivates students to participate in classroom activities. Naylor and Keogh (2013) find that concept cartoons are highly motivating in various situations for student groups of all ages, including students with emotional and behavioral difficulties. Fenske et al. (2011) show that concept cartoons contributed to students' motivation. Chin and Teou (2010) sign that concept cartoons can be used as a visual stimulus to motivate students.

Third, our intervention enhanced the experimental group students’ speaking skill scores. Besides, the effect size revealed that this difference was also significant in practice. This result is consistent with the studies in the literature. According to Chin and Teou (2009), using concept cartoons in lessons enables students to speak up and allows for interactive discussions. Sexton et al. (2009) state that concept cartoons provide a useful context for creating discussion. Webb, Williams, and Meiring (2008) determine that concept cartoons contribute to the student's level of discussion and thinking. Morris et al. (2007) demonstrate that concept cartoons can be used as stimulating material to initiate discussion. In this context, we can say that using concept cartoons also provides an English language teaching process in which the language is used communicatively.

Based on the results, it can be stated that the discussion environment created in the classroom has a positive effect on achievement by broadening the student's perspective in English language teaching supported by concept cartoons. Besides, it can be said that the free expression of each student's opinion on concept cartoons in the classroom contributes to the conversation. Thus, concept cartoons can be beneficial for the development of students' foreign language speaking skills. So, it is possible to say that English teachers who make use of concept cartoons in their lessons could motivate their students.

It is hoped that this research will be a guide for future research as an exemplary study to gain concept cartoons, which are generally visual materials used in science lessons, to the methods used in English language teaching. However, this research has some limitations as only quantitative data collection tools were used. In this context, a mixed study could be conducted in which quantitative and qualitative data collection tools are used together. Moreover, research could be done on the use of concept cartoons in teacher education because it is believed that teachers should integrate concept cartoons into their lessons.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

This article is based on Hülya Baysal's dissertation study named "The Effect of Using Concept Cartoons on Students' Achievement, Speaking Skill and Motivation in the Sixth Grade English Course" which was conducted under the supervision of Dr. Selcen Gültekin.

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Research involving Human Participants and/or Animals

Research permission was obtained from the Balıkesir Provincial Directorate of National Education on 09/09/2019 before the data collection tools were developed and before the implementation was carried out.

Kavram Karikatürlerinin İngilizce Öğretimindeki Öğrenci Başarısına, Konuşma Becerisine ve Motivasyonuna Etkisi

Özet:

Birçok farklı öğretim yöntemi denenmiş olmasına rağmen İngilizce öğrenme sorunu devam etmektedir. İngilizce öğretiminde diyalojik konuşmaya olanak sağlayan kavram karikatürlerinin bu sorunun çözümüne katkı sağlayacağı düşünülmektedir. Bu çalışma, altıncı sınıf İngilizce dersi "Yummy Breakfast" ünitesinde yer alan kavram karikatürlerinin öğrencilerin başarısına, konuşma becerilerine ve motivasyonuna etkisini incelemektedir. Araştırmada ön test son test kontrol gruplu yarı deneysel desen benimsenmiştir. Deney grubunda 18, kontrol grubunda 15 olmak üzere toplam 33 altıncı sınıf öğrencisi bulunmaktadır. Deney grubuna kavram karikatürleriyle desteklenmiş İngilizce eğitimi verilirken, kontrol grubuna geleneksel eğitim verilmiştir. Çalışma, iki saatlik ön test, 18 saatlik deneysel uygulama ve dört saatlik son test dahil olmak üzere 24 saat sürmüştür. Araştırmanın sonucunda kavram karikatürlerinin öğrencilerin konuşma becerilerini ve motivasyonunu geliştirdiğine ulaşılmıştır. Bununla birlikte, öğrencilerin başarı puanları arasında anlamlı bir farklılık bulunmamıştır.

Anahtar kelimeler: İngilizce kavram karikatürleri, İngilizce öğretimi, akademik başarı, konuşma becerisi, motivasyon

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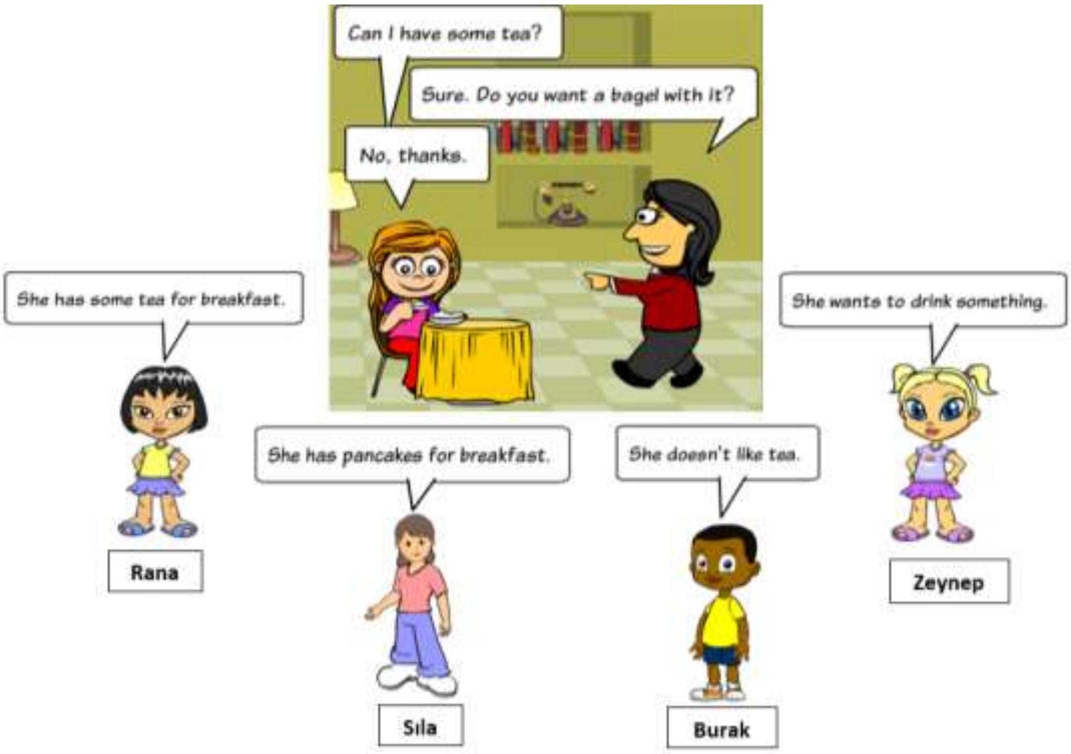
Appendix 1

Listening
E6.2.L1. Students will be able to identify the names of different food in an oral text.



1. Which ideas that characters express are acceptable? Tick (✔) them.

Rana ☐ **Sıla** ☐ **Burak** ☐ **Zeynep** ☐

2. Write down your ideas.

……………………………………………………………………………………………

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Research Article

Science Curricula and Science Teachers Training in Turkey: Past, Present and Future

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Abstract – The article highlights the challenges to science curricula and science teaching programs in Turkey and analyzes both these challenges and the opportunities that exist for teachers, teacher educators, policymakers. The aim of this literature review is to identify the historical development of the science curricula and the policies for science teacher training in Turkey. This research encompasses an analysis of the science curricula from before 2005, and those of 2005, 2013, and 2018, focusing on their alignment with educational needs, expectations, and curriculum outcomes. The evolution of science teacher training programs in Turkey for the years 1998, 2007, and 2018 has been assessed, and potential future modifications to these programs have been deliberated. The findings reveal that although curricula have been progressively updated to meet contemporary standards, teacher training curricula have not kept pace, resulting in numerous issues including compromised education quality and performance in international exams. The review offers recommendations for educational practices, emphasizing the need for coordinated efforts between the Ministry of National Education in curriculum development and the Turkish Council of Higher Education in shaping teacher training policies.

Key words: Science curriculum, Teacher training, Science education, Turkey.

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Introduction

Different science curricula have had different balances between the needs of science and scientists, of students, and of society (Childs, 2015). The development of new curricula is a common occurrence in countries around the world (Rogan & Grayson, 2003). Although the first changes in science curricula originated from the establishment of countries, political, social and scientific developments also had an effect on the changes that occurred until the following years (Bakaç, 2019). The increasing number of students and teachers, innovations in educational philosophy, the addition of new learning areas (Ünsal et al., 2008), changes in the number of subjects and curriculum outcomes (Kurtuluş & Çavdar, 2011), changes in national placement exams (Koç et al., 2008), changes in the compulsory school year (Karatay et al., 2013; Ministry of National Education [MoNE], 2013), innovations in measurement and evaluation techniques (Özyurt et al., 2014), low-performance results in exams such as PISA and TIMSS (Çakır & Yaman, 2018; Yaz & Kurnaz, 2020), engineering and technology innovations, and the country's socio-economic development plans (Güneş et al., 2018) effects curriculum reforms. Turkey, with a population of eighty-three million people, is the second most crowded country in Europe. While 1.629.720 of the students in formal education are preschoolers, 5.279.945 students are at a primary school level, 5.701.564 students are at a middle school level and 5.630.652 students are at a secondary school level (MoNE, 2019a). The number of students in Turkey is higher than that of those in most of the European countries. More than one million teachers have been employed in educational institutions (MoNE, 2019a). Understanding how and why the education system has developed and changed over time will enable readers to appreciate the present-day challenges faced by science teacher educators, researchers, teachers, and students and offers some context for considering what issues are significant to address in the future (Faisal & Martin, 2019). This literature review highlights the challenges to science curriculum and science teaching programs in Turkey and analyzes both these challenges and the opportunities that exist for teachers, teacher educators, policymakers.

Aim of the Literature Review

The objective of this literature review is to examine the historical and current states of the science curriculum and science teacher training programs in Turkey, with the aim of understanding the interrelationship between them. The review also seeks to explore the implications of these programs by forecasting potential future developments. By considering the trends in science teacher training and science curriculum development within Turkey's social, political, and educational contexts, the review addresses the following questions:

- What are the historical changes in the development of the science curriculum in Turkey, and how might these influence its future trajectory?

- What have been the defining features of science teacher education in Turkey historically and in contemporary times, and what are the potential future implications of these characteristics?

The Importance of Literature Review

As part of this literature review with national and cultivating change science education and science teachers in Turkey in the international arena in the past and is intended to provide information and publicity about today's developments. It also provides predictions about possible future changes. Different studies have examined the changes in the education programs of different countries. Tuan and Lu (2019) examined science teacher education in Taiwan by dividing it into three parts according to years. In the first part, between 1949-1994 (being a sufficient science teacher and a good role model), in the second part, between 1994-2017 (being a professional science teacher and a good role model), and in the third part, between 2018 and later (science teachers that questions and can integrate different disciplines) were considered. In addition, in the last section, the society's view on the science teacher certificate is mentioned. Similarly, Wei (2019) explains that regarding the science teacher in Macau, the autonomous state did not have an educational innovation until 1999, and after this date, after being connected to China, the personnel rights of science teachers were improved. It has also been stated that science teachers have difficulty in subjects that require the integration of interdisciplinary education, such as STEM. Again, in Park's (2019) study, he focused on the history of the appointment of science teachers in Korea according to their graduation level, their graduation from universities or colleges today, and the skills that science teachers should acquire in the future. In these studies, the past and present of science teacher education in the subject countries are discussed in order to determine or predict the future. Particular emphasis is placed on interdisciplinary integration, which is a trending education approach. Similarly, with the spread of STEM education in our country, curriculum updates and engineering applications subjects have been added in parallel. In addition to these studies, Faisal and Martin, (2019) focus on science education with the history of pre-service and in-service training of science teachers in Indonesia. It appears that the researchers also addressed innovations in science curricula in Indonesia, student learning, and teachers' challenges. In addition, the study includes suggestions for increasing the rate of schooling and doing science and the quality of teachers. Apart from these, Kang (2019) focused on the past, present and future of science education for gifted students in Korea. Gilbert et al. (2003) summarize the past, present and future of research in the field of science education worldwide. Rennie and Stocklmayer (2010) conducted research on the past, present and future of the development of science and technology, focusing on the role of it in social learning. In their study, Zohar and Barzilai (2013) analyzed the articles in the ERIC database and made predictions about the current status and future of metacognitive development of publications in science education. Based on all these publications, it becomes clear that a similar study should be conducted in Turkey. It is important to analyze the historical development, current situation and future of science teacher training in Turkey and similar developments in science curricula. In these studies, the development of science education and the historical change in the training of science teachers are discussed. The main purpose of these studies is to introduce the situation in their country at national and international levels. Similar goals are used in research on the historical development of science education or science teachers (Rudolph, 2008). Especially in terms of science education examining up to change and development since Turkey's establishment is of great importance. In the literature, it is possible to find studies comparing student and teacher training between countries (Geesa et al., 2019). This study of science education related to Turkey, is thought to be the source for this type of work. It is thought that by giving the development process of science education in detail and in-depth, it will set an example for future studies or updates. Similarly, it is believed that changes in teacher training can be followed. In addition, research in different countries, is the source for the data belonging to Turkey for researchers.

The role of science teachers in delivering science education, as guided by the science curriculum, holds significant importance at both national and international levels (Peker & Dolan, 2014). It is inevitable to update science curricula due to reasons such as the development of technology, the structuring of knowledge, the social effects of science, the impact of knowledge on solving daily life problems, the acquisition of twenty-first century skills, global innovation studies and the economic-industrial development goals of countries. As a matter of fact, there are updates in science curricula. Similarly, science teacher training also needs to be updated. By updating science curricula according to interdisciplinary integration, science teacher training programs also need to be updated. The increase and importance of science communication requires the integration of scientific innovations for the benefit of society into the curriculum and teacher training programs. The need for new generations of qualified questioners requires the development of science curricula and therefore the updating of science teacher training programs. Because it is the teachers who will implement the science curriculum. Having the two updates in parallel will make science education healthier. For these reasons, the historical development, current situation and future of both science curricula and teacher training programs should be analyzed. In this way, it is important to obtain a situation report for Turkey and shed light on future studies and policies.

Method

This research was conducted with the document analysis method, which is evaluated within the scope of the literature review. The research presented in the content of this method is the detailed investigation of the subject determined among the available resources and the systematic collection of the subject (Fraenkel & Wallen, 2006). Data regarding the science teacher training program and science curriculum in Turkey were identified, interpreted, estimated and evaluated. Within the scope of the literature review, a document analysis was conducted, involving the examination of written and visual documents containing comprehensive information and insights relevant to the research topic. This process involved scrutinizing related publications in the literature. Document analysis entails the thorough evaluation of documents to extract relevant data and understandings pertinent to the research subject. (Creswell & Plano Clark, 2011; Glesne, 2013).

Table 1 Analyzed Contents

Categories	**Analyzed Documents**	**Title and content**
MoNE Science Curriculum	Elementary science curriculum (1924) Elementary science curriculum (1926) Elementary science curriculum (1938) Elementary science curriculum (1949) Elementary science curriculum (1969) Elementary science curriculum (1974) Elementary science curriculum (1992) Primary science curriculum (2000)	Science Curriculum Before 2005
	Science and technology curriculum (2005)	2005 Science Curriculum
	Science curriculum (2013)	2013 Science Curriculum
	Science curriculum (2018)	2018 Science Curriculum
Turkish Council of Higher Education (CoHE) Science Education Teacher Training Programs	Teacher training curriculum (1998) Content of undergraduate science education (2007)	Teacher Training in the Past
	Content of science undergraduate education (2018)	Teacher Training in the Present

Table 1 shows the analyzed contents of science curriculum and science teacher training programs. We tried to reach all the science curriculum since the foundation of the republic. In this context MoNE (1974, 1992, 2005, 2013, 2018) science curriculum examined. In addition, five updates of MoNE before 1974 were also examined (MoNE was established in 1920). The CoHE teacher-training program (1998, 2007, and 2018) analyzed. In this review, the curriculum outcomes, contents, education process and evaluation dimensions of the programs were discussed. All of these dimensions are mentioned below under the headings of the relevant years. The publications in this context were analyzed descriptively. It covers presenting existing data with numerical values and classifications to the reader in a more fluent and descriptive manner (Yıldırım & Şimşek, 2013). This analysis in the context of educating science teachers and science curriculum changes occurring in Turkey, starting from the 1920s to the present day has been reported. Based on these data, the estimates for the future of science education and science curriculum have been established in Turkey.

Results

In order to interpret the historical evaluation of Turkey's science curriculum and its impact on future development, the curricula need to be examined in detail. We used before 2005, 2005, 2008, 2013 and 2018 definitions to examine the changes in science curriculum. Because 2005 is accepted as a period when reform movements started.

Science Curriculum Before 2005

It has been found out that nine different regulations had been made in science programs between 1923, when the Republic of Turkey was founded, and 2005. Those regulations were mainly aimed at promoting the Republic regime and making it widespread. At the same time, the prominent scientists worldwide, like John Dewey (Erdoğan, 2007), were consulted on the issue. In the following years, the updates continued to be made depending on the scientific and sociological developments in Turkey and around the world. In the 1940s, the emphasis in the curricula being updated overtime was on the curriculum outcomes such as having curiosity, displaying a positive attitude, and understanding the importance of science. It was also suggested that education should be student-centered. In the 1970s, it was pointed out that the use of science in everyday life problems as necessary. As of 1992, the curriculum outcomes came to the forefront, such as being able to do experiments and observations, using one’s own mind, and also being able to relate science and technology with each other. With a radical decision being taken in 1996, elementary schools (five years) and middle schools (three years) were integrated with each other, and compulsory primary education was enacted for the first time in the history of the republic. Elementary schools and middle schools were all renamed as primary schools. For such reasons, there became a change again in 2000. In the 2000s, the skills and the curriculum outcomes, such as collecting, analyzing, and presenting data, gained importance. In general, the courses were teacher-centered and based on the students' doing homework (Ayas et al., 1993; Bakaç, 2019; Yurdatapan, 2011). Table 2 shows the updates in science curricula between 1924 and the 2000s.

Table 2 Updates in Science Curricula before 2005

Year	Course name	Subjects	Course Hour	Source
1924	Nature and Objects Sciences	These courses were given separately: Animals, Plants, Hygiene, Physiology, Physics, Chemistry and Science Applications.	8 hours	Bakaç (2019), Yurdatapan (2011)
1926	Nature and Objects Sciences	These courses were given separately: Animals, Plants, Physiology, Physics, Chemistry and Science Applications.	4 hours	Bakaç (2019), Erdoğan (2007)
1938	Natural Sciences	Zoology, Botany (also Physics)	3 hours	Budak & Budak (2014)
1949	Natural Sciences	Living creatures, Human body, Systems, Animals, Plants (also Physics)	3 hours	Yurdatapan (2011)
1969	Science and Natural Sciences	Scientists, Substance, Living creatures, Animals, Weight, Heat, Body, Plants, Weather, The Earth, The Sun, Light, Chemistry	3 hours	Erdoğan (2007), Yurdatapan (2011)
1974	Science	It covers the subjects of Physics, Chemistry and Biology.	3 hours	MoNE(1974), Yurdatapan (2011)
1977	Science		4 hours	Yurdatapan (2011)
1992	Science		3 hours	MoNE (1992)
2000	Science		3 hours	Erdoğan (2007), Yurdatapan (2011)

According to Table 2, the updates in the science curricula in 1924 and 1926 mostly included the courses consisting of the science subjects, which were given separately. In addition, the name of the course was "Nature and Objects Sciences". It is understood that the Physics subjects were still being taught both in 1938 and 1949 although the course was called "Natural Sciences". The course which was named "Science and Natural Sciences" in 1969 was later renamed "Science" in 1974. It is understood that Physics, Chemistry, and Biology were now in the same curriculum. The course hours above have been given on a weekly basis. In addition, it is known that in some years there was an increase or a decrease of one hour in accordance with the class level. It is understood that Physics, Chemistry or Biology subjects were all included in science courses, or they were given separately although the science courses generally had different names in all years.

2005 Science Curriculum

MoNE updated the science curriculum with the purpose of making a contribution to individual skills, such as science literacy, researching and questioning, problem-solving, critical thinking, and decision-making in 2005. What is remarkable in this curriculum is that the principle that an individual can learn for a lifetime was added into it (Tekbıyık, 2018; Tüysüz & Aydın, 2009). In addition, it was decided that the science curricula should be prepared from that day on by taking the opinions of the academicians, field specialists, parents, students, and teachers (Erdogan, 2007). The subjects of Technology, Society and Environment were also added into the curriculum besides Physics, Chemistry, and Biology, and the course name was changed to "Science and Technology" (MoNE, 2005).

The teacher-centered structure of the curriculum was changed, and the curriculum was developed with student-centered approaches and constructivist philosophy. The curriculum for science and technology courses adopted such principles as constructivist learning, science and technology literacy, new and alternative evaluation techniques, physical and mental development of the students, spiral principle, integrating all disciplines, meaningful learning, and the view that less knowledge is more (Özdemir, 2007). The subject areas in this curriculum were presented in four different categories. The main subjects were determined to be ‘Living Creatures and Life’, ‘Matter and Change’, ‘Physical Events’, and ‘the Earth and the Universe’(Ünsal et al., 2008). Although there were four different subjects determined, three new subject areas were also added into the curriculum, which are Science-Technology-Society-Environment, Scientific Process Skills, and Attitudes and Values (MoNE, 2005).

It has been found out that there were some negative thoughts about the 2005 science curriculum besides the positive ones although the curriculum was thought to be great by the teachers when it was first enacted. When compared to the previous curricula, this curriculum and the changes in it were positive in general (Bukova et al., 2005; Coşkun, 2005; Erdoğan, 2007). It is possible to say that the new curriculum had a positive effect on students’ learning (Delen & Kesercioğlu, 2012). It has been determined that the students who were educated under the 2005 science curriculum enjoyed the courses (Çeken, 2010). Moreover, it has been found out that the participation of students in the courses increased positively with the new curriculum (Aydın & Çakıroğlu, 2010; Küçüköner, 2011).

The science curriculum had some aspects which were thought to be negative as well as positive ones (Dindar & Yaygın, 2007). First of all, the fact that it was an unusual curriculum gave rise to a bias. The application of the curriculum was negatively affected by some reasons. For example, the curriculum was found to be overly extensive, encompassing numerous subjects and skills, coupled with an excessive number of student activities. This complexity made it challenging for students to complete their homework. Additionally, there was a notable scarcity of materials and equipment, further compounded by the issue of overcrowded classrooms. The most negative thing was that the courses were still teacher-centered (Doğan, 2010; Kurtuluş & Çavdar, 2011; Özdemir, 2007). It has been determined that the teachers had difficulty in telling the subjects in a timely manner and doing laboratory activities (Şengül et al., 2008). It has been observed that the negative aspects of the curriculum consisted of the problems arising from the fact that professional development seminars were introduced inadequately, the teachers were not informed about the alternative measurement and evaluation techniques in the curriculum, and science subjects requiring mathematical skills were told before the math's subjects (Bütüner & Uzun, 2011). In addition to these, there was another problem arising from the fact that the eighth graders at the middle school level took private lessons outside of the school. In the examination the students entered for passing to an upper class, there were some questions, which were out of the subjects and outcomes in the curriculum (Koç et al., 2008). It has also been found out that some teachers had difficulty in the application of Science-Technology-Society-Environment, Skills, and sensorial curriculum outcomes (Buluş-Kırıkkaya, 2009). For all these reasons, it was inevitable for the curriculum to be changed again.

2013 Science Curriculum

The science curriculum was updated when eight-year compulsory primary education changed into 12-year compulsory education, which involved an education period with four years of elementary school, four years of middle school and four years of high school with the regulation made in 2012. 2013 curriculum started to be gradually implemented in third grades at the elementary school level, fifth grades at the middle school level, and nineth grades at the high school level. With this curriculum, the "Science and Technology" course was renamed "Science". The 2013 curriculum was based on "research and inquiry" instead of constructivism although the vision of this curriculum was not different from that of the 2005 curriculum (Benli Özdemir & Arık, 2017; Karatay et al., 2013; Keskinkılıç Yumuşak, 2017; MoNE, 2013).

The curriculum mentioned here had four main subjects with four learning areas, which are 'Living Creatures and Life', 'Matter and Change', 'Physical Events' and 'The World and The Universe' for called "Knowledge", Scientific Process Skills for called "Skill", Attitudes and Values for called "Sensorial" and "Science-Technology-Society-Environment". Subjects and learning areas were integrated with each other. The aim in the integration of the subjects with the learning areas was to make the individuals science-literate, who have developed general and sensorial skills in Science-Technology-Society-Environment, besides having the basic knowledge (Karatay et al., 2013; MoNE, 2013).

Although the 2013 curriculum had more positive aspects than the 2005 curriculum in general, it is also understood that it had also some negative or incomplete aspects. Some of the innovations with this curriculum, which are thought to be generally positive, were that the students' readiness levels were taken into account in the preparation of the curriculum, there were fewer curriculum outcomes, the process was being evaluated, and the curriculum outcomes that could support the development of students' cognitive, sensorial and psycho-motor characteristics were integrated with the curriculum outcomes of the subjects (Özcan & Küçükoğlu, 2014; Tekbıyık, 2018; Toraman & Alcı, 2013). Furthermore, the order of the subjects was changed, and what is most important is that the changes were made in accordance with the other courses. The subjects were told in the same order as the Mathematics subjects or other disciplines. It is stated that especially the decrease in the number of curriculum outcomes was positively welcomed by the teachers (Keskinkılıç Yumuşak, 2017).

It has been found out that one of the negative aspects of the 2013 science curriculum was that there were no exemplary practices in teaching and evaluation processes. Another one was that alternative evaluation techniques were not introduced, and they were not supported with any example (Özata-Yücel & Özkan, 2013; Özyurt et al., 2014). It has been observed that the curriculum outcomes in the 2013 curriculum mostly remained at the level of knowledge, and the number of curriculum outcomes at the conceptual level was higher especially in the upper classes. It is known that this curriculum, which aimed to prepare the students for higher education, had a limited number of curriculum outcomes to stimulate the ability of high cognitive thinking (MoNE, 2013; Yaz & Kurnaz, 2017). As a result, the 2013 science curriculum went through a change in 2018. Although this change was caused by the above-mentioned negative aspects, it is thought that the political-educational problems that arose after the coup attempt in Turkey in 2016 could also be one of the reasons for the change in the curriculum.

2018 Science Curriculum

The science curriculum was issued as a draft in 2017 and organized with the consultation of the academicians, teachers, and parents, and it was implemented in 2018. It has been observed that the learning areas in the 2018 curriculum, which are knowledge, skills, sensory skills, and Science-Technology-Society-Environment, remained the same when compared to the ones in the 2013 science curriculum. Only some of them had minor changes in it (Candaş et al., 2019). On the other hand, the number of subjects (‘Living Creatures and Life’, ‘Physical Events’, ‘Matter and Nature’, ‘The Earth and The Universe’) was increased from four to five. With the newly added subject areas of “Science and Engineering Applications”, the students were expected to understand the importance of science and scientific processes. In addition, the aim is the integration of engineering with technology was to raise the students’ awareness of the scientific developments that would be beneficial for the socio-economic development of the country (Güneş Koç & Kayacan, 2018). Moreover, the targeted products in the fields of science and engineering were decided to be presented through such events as a project exhibition and a science fair. Science festivals, where the products made in the school environment will be exhibited, were aimed to be arranged. Furthermore, it is thought that increasing STEM education approaches were effective in the addition of these subject areas (Bakırcı & Kutlu, 2018).

The number of outcomes in the curriculum was slightly reduced. The aim here was to have unity in the implementations by clarifying the limitations and explanation parts of the curriculum outcomes. The attention was particularly paid to the association of the curriculum outcomes with daily life. The aim of avoiding the curriculum outcomes that could create an information overload was to make it more interesting. In this context, the evaluation part of the curriculum was prepared in accordance with the international standards. Especially the evaluation systems such as TIMSS and PISA, which have been held worldwide, were taken into account. Moreover, the measurement and evaluation methods and techniques were exemplified (Cengiz, 2019).

Providing teacher guidance was emphasized in the curriculum to be important as well as having a student-centered structure. Furthermore, the values education of teachers, which existed in the curriculum in an implicit manner, was given importance. Such skills as having universal, moral, and cultural values and decision-making were also mentioned in the curriculum (Deveci, 2018). The curriculum centered upon research and inquiry although there was no change in its philosophical and theoretical structure. Apart from these, scientific processes, life skills, and innovative and entrepreneurial thinking skills were highlighted in the context of 21st-century skills (Deveci et al., 2018; MoNE, 2018). Interdisciplinary relations were made in an implicit structure in the curriculum. There were no direct curriculum outcomes from the other disciplines, and the repetitions were avoided accordingly. The attention was paid to the harmonious time frames of the curriculum outcomes associated with the other disciplines. The subjects told at some different class levels were replaced with each other (Bahar et al., 2018).

The 2018 science curriculum is generally regarded as positive in all respects (Özcan et al., 2018; Saraç & Yıldırım, 2019). It is known that some of the teachers stated that they might need a separate draft or booklet for measurement and evaluation apart from the curriculum. It is thought that the curriculum outcomes were still too many although the number of them was reduced (Cengiz, 2019). Apart from these, there is a concern that there might be a problem due to the teachers' inadequate knowledge in the practices of science and engineering (Özcan et al., 2018; Saraç & Yıldırım, 2019).

Potential Directions for Future Science Curricula

It is possible to say that it was after the 2000s that there were different and permanent changes in the science curricula (Benli Özdemir & Arık, 2017). It is also possible to state that these changes were positive and innovative in general (Karatay et al., 2013). Today's curriculum has been shaped by many types of research and interviews. The changes in the curricula are the result of the political, economic, and social developments in the country. Turkey has gone through a continual revision process, considering the national and international variables. Regulations and continuity, in this sense, are good in a general term. According to Table 3, which shows the three important changes after the 2000s, it is possible to say that the numbers indicate how significant the changes in the curricula are.

Table 3 Comparison of the Science Curricula Subjects in 2005, 2013 and 2018 in Terms of the Curriculum Outcomes and Course Hours

Science Curriculum Subjects	Number of Curriculum Outcomes			Course Hour		
	2005	2013	2018	2005	2013	2018
Living Creatures and Life	221	78	73	180	174	150
Physical Events	299	84	75	178	202	198
Matter and Change	194	65	52	166	126	108
The Earth and The Universe	93	39	27	52	74	72
Science and Engineering Applications	-	-	15	-	-	48
Total	807	266	242	576	576	576

Table 3 has been prepared according to the science curriculum (for fifth, sixth, seventh and eighth grades). As it is seen in Table 2, while the 2005 and 2013 curricula cover four subjects, the 2018 curriculum also include the fifth subject, which is "Science and Engineering Applications". As a matter of fact, this field shows hope for science education

(Thiry et al., 2017). The number of curriculum outcomes was reduced from 807 in 2005 to 266 in 2013. Then, with the change in 2018, the number of curriculum outcomes was reduced to 242. In all curricula, the course hours are the same, which are 576 for each. However, it is clear that the number of course and hours depending on the subjects differs from one another. There is probably going to be a decrease in the number of curriculum outcomes and the course hours in the future. But rather, it seems to be a matter of debate how the curriculum outcomes will be achieved.

The process of the coronavirus, which has affected the world like a pandemic, shows that the question of where and how the curriculum outcomes will be achieved is more important than the number of the course hours or the curriculum outcomes. The technological infrastructure of all the schools in Turkey has been strengthened with "Fırsatları Arttırma ve Teknolojiyi İyileştirme Hareketi (FATİH)" (The Project of Increasing Opportunities and Improving Technology). In general terms, the interactive boards and the internet can be used easily in the courses. In addition to the technological infrastructure of the schools, the courses were continued through "the Education Information Network" during the epidemic period. Moreover, the education process at all class levels has continued with EBA television channels. Apart from all these, the schools have prepared online courses for the students with their own means. This platform provides such opportunities as maintaining the education process and making evaluations in traditional ways. During the pandemic process, this platform has begun to be used more effectively. It is clear that EBA is an instrument that can be used efficiently in the pandemic process. It is thought that the measurement and evaluation parts of the platform should be improved (Sarı, 2020). According to the data released by the "Turkish Statistical Institute" in 2019, 75.3 % of the people in Turkey use the internet. However, it is thought that participation and motivation are not at an expected level although the online courses are supported by television (Sarı & Nayır, 2020). It is thought that the following education curricula will focus on the efficiency of online education. Online education will be used in the technology part of the curriculum, and it will be activated in any case of a disruption in education. It is thought that the studies will be especially carried out on the development and dissemination of the measurement and evaluation techniques in online education.

Although there is an overall and a rapid improvement in the number and type of the curriculum outcomes, it is thought-provoking that most of the outcomes in the current curriculum are at a basic level. There should be curriculum outcomes that appeal to the high cognitive levels of the students (Yaz & Kurnaz, 2017). The curriculum outcomes should include scientific and social information, enable the individuals to think and allow them to produce alternatives, thus making them find creative solutions with an investigative spirit. In other words, the curriculum should also enable the individuals to learn the information, methods, and techniques which they can use to solve daily or social problems, rather than only getting information and passing it to an upper class (Doyle et al., 2020). In addition to the science curriculum, the basic characteristics of historical and contemporary science teacher education in Turkey and its effects on the future are presented below.

Historical Overview of Teacher Training

As the Republic period was underway, teacher training was one of the issues that require urgent solutions as a very important problem. With “The Law of Education System” in 1926, the teacher training schools were classified as “The First Teacher Training Schools” and “Village Teacher Training Schools”. In the 1927-1928 academic years, a teacher training curriculum was prepared for the schools in the rural areas, and two "Village Teacher Training Schools" were opened in Denizli and Kayseri provinces to train teachers for the village schools. However, this curriculum, which was used for four years, failed to meet the expectations (MoNE, 1992). Until 1948, 21 village institutes were opened in various parts of the country, and additionally, a high village institute that provided three years of higher education to train temporary head teachers and supervisors in primary schools was established in the Hasanoğlan Village Institute. The teachers in the village institutes were trained to work in the villages and to support the regional development because, in those years, 80% of the population is known to have been living in the villages (Şeren, 2008). Until 1953, there were two types of teacher training policy for primary schools; the institutions which were training teachers were united under the name of "The First Teacher Training Schools” after 1953. These schools gave education for 6 years after elementary school and for three years after middle school. From the foundation of the Turkish Republic to the early 1990s, there was a constant change in general terms, and the graduates of Physics, Chemistry, and Biology, who were trained as high school teachers, began to teach at middle schools as science teachers. As of 1992, the fact that the universities started to train science teachers has been an opportunity to improve education and to increase the quality in this field. Until 1998, only Gazi Faculty of Education and Buca Faculty of Education trained teachers in the field of Science, and these faculties implemented the curricula in a way that they determined themselves (Meriç & Tezcan, 2005).

Current State of Teacher Training

Within the framework of the reconstruction since the 1998-1999 academic years, the science teaching curriculum has been published by CoHE and sent to the faculties for implementation. Of the 97 faculties of education, 66 have a science teaching department and they have been training teachers in the field of science.

Table 4 A Comparison of the Course Hours in Theory and Practice of the Professional Knowledge Courses in Science Teaching Department

	Theoretical course hours (T)	Practical course hours (U)	Course credit (K)
1998	130	50	157
2007	132	42	153
2018	130	36	148

Table 4 shows that the least course hours in the practical courses belong to the year 2018 when the updates in 1998, 2007 and 2018 are compared depending on the theoretical and practical hours of the professional knowledge courses in the science teaching department (CoHE, 2007, 2018). When the contents of the courses are examined, it is understood that the theoretical course hours remain constant over the years.

Courses in science teaching department are divided into three sections: field education courses (F), professional teaching knowledge courses (PT), general culture courses (GC). Among the field courses, there are also Physics, Chemistry, Biology and Mathematics included, which are the major science courses. In 2018, CoHE, which is responsible for teacher training, updated the teacher training curricula. The percentage of the professional teaching knowledge courses in the curricula is 30-35%; general culture courses15-20%; and field education courses 45-50% (Turkish Education Association [TEDMEM], 2019). Professional knowledge courses consist of educational sciences, science teaching, interdisciplinary science teaching and science laboratory courses. General culture courses are the courses thanks to which the teacher candidates can keep up with the new conditions of the changing world. Four years of teacher training process has been divided into 8 semesters. Table 5 shows the courses given in these 8 semesters.

Table 5 Course Contents in Science Teacher Training

First Year	Second Year	Third Year	Fourth Year
First Semester Courses	Third Semester Courses	Fifth Semester Courses	Seventh Semester Courses
History of Turkish Revolution and Ataturk's Principles-1 (GC)	Teaching Principles and Methods(PT)	Turkish Education System and School Management(PT)	Teaching Practice-1 (PT)
Turkish Language-1 (GC)	Research Methods in Education(PT)	Measurement and Evaluation in Education(PT)	Guidance at Schools(PT)
Foreign Language-1 (English German or French) (GC)	Approaches in Science Learning and Teaching (PT)	Science Teaching-1 (F)	Interdisciplinary Science Teaching (F)
Information Technologies	Biology-2 (F)	Science Teaching Laboratory Applications-1 (PT)	Environmental Education (F)
Introduction to Education (PT)	Physics-3 (F)	Astronomy (F)	Professional Knowledge.Elective-5 (PT)
Philosophy of Education (MB)	Chemistry-3 (F)	Professional Knowledge. (PT)	Elective-5 (Human Anatomy and Physiology) (F)
Physics-1 (F)	Vocational Elective-1 (F)	General Culture-Elective-3 (GC)	Elective-5 (Evaluation of In-Class Learning) (PT)
Chemistry-1 (F)	General Culture Elective-1 (GC)	Elective-3 (Renewable Energy Sources) (F)	
General Mathematics-1 (F)	A. Elective-1 (Biological Resources of Turkey) (GC)		
Second Semester Courses	Fourth Semester Courses	sixth Semester Courses	Eighth Semester Courses
History of Turkish Revolution and Ataturk's Principles -2 (GC)	Turkish History of Education(GC)	Morals and Ethics in Education(PT)	Teaching Practice-2 (PT)
Turkish Language-2 (GC)	Teaching Technologies(PT)	Classroom Management(PT)	
Foreign Language-2 (English, German, French) (GC)	Community Service Applications(GC)	Science Teaching-2 (F)	
Educational Psychology (PT)	Science Curricula(PT)	Science Teaching Laboratory Applications-2 (PT)	
Sociology of Education (PT)	Biology-3 (F)	Scientific Reasoning Skills (F)	
Physics-2 (F)	Geology(F)	Professional Knowledge. Elective-4 (MB)	
Chemistry-2 (F)	Professional Knowledge Elective-2 (PT)	General Culture. Elective-4 (GC)	
Biology-1 (F)	General Culture. Elective-2 (GC)	Elective-4 (Material Design in Science Teaching)(PT)	
General Mathematics-2 (F)	A. Elective-2 (Applications of Science in Technology)		

Table 5 shows the courses taken by the science teacher candidates in the faculty of education. All universities provide the same subjects for the teacher candidates although each of the subjects has a different name within the framework of the universities' academic structure. During the academic period of the faculties, the educational courses are given by the academicians with general educational backgrounds while the science-related courses are given by academicians who are experts in their fields. In general, the subjects told by field experts are selected to be at a challenging level for teacher candidates.

It has been observed that the curriculum does not have applications that can provide socialization and motivation. It is also clear that there are no contents such as 21st-century skills, research and inquiry applications, or STEM education. In addition, the teacher candidates are settled in this department according to the superiority of the scores they have had. Their interests, needs, and vocational tendencies are not taken into account either before or after the academic period. Those teacher candidates, who complete the academic period, take the public personnel selection examination and the field examination. The average scores of the candidates taking the field proficiency tests are the lowest ever obtained especially from higher education transition exams in the field of science in recent years (TEDMEM, 2019). If they succeed in these examinations, the oral interview process on teacher proficiency begins with the establishment of central commissions. The teacher candidates, who become successful in the interview, are subjected to the central appointment according to their score superiority. After that, they are obliged to serve for at least three years under contract in the region where they have been appointed.

Future Prospects in Teacher Training

Educational reforms are directly linked to teacher training (Ültanır & Ültanır, 2018). While MoNE determines the needs for teacher training, CoHE is the institution that responds to these needs. Accordingly, MoNE policies should be participatory, data-based, holistic and long-term. The aim of the document “2023 Education Vision for a Strong Future” prepared and published by MoNE was to address the shortcomings in the implementation. In this document, it is notable that there are the subjects such as the formation of the institutions that train teachers, professional development, personal rights, the improvements in different types of employment and the teaching profession law. This can be interpreted as the evaluation of the teaching profession as a whole (MoNE, 2020). In most institutions in Turkey, there is a gap between education curricula and the contextual needs of the teachers (Balbay et al., 2018). “A school is just as good as the teachers in it” (Kavcar, 2002). Increased awareness that "quality in education is the key to success" has led to the innovations and therefore the progress. With the rapid development of digital technologies and their use in the education and training process, it is necessary to add programs for the recognition and use of these technologies in teacher training programs (Thiry et al., 2017; Thoma, 2019).

It has been determined that teachers have difficulties in using these technologies, especially in the distance education process, which has increased in importance with the epidemic period (Sarı & Nayır, 2020). Science teachers should have training to use digital technologies not only for the future, but also from now (Webb, 2019; Zhu & Liu, 2020). Finally, in the selection of future science teachers, teacher candidates' interests and abilities should be considered. A science teacher candidate to the exam center program in Turkey is taken. These candidates are placed on the basis of getting points by solving the right questions from any discipline in the exam they take (CoHE, 2020). It can be expected that the willing candidates will be selected and enjoy disciplines such as physics, chemistry, and biology, and solve some of the questions arising from these disciplines.

Discussion and Conclusion

In this literature review, which is about the past, present, and future of science curricula and science teacher training in Turkey, it has been found out that primary education should be in compliance with undergraduate curricula in terms of philosophy, purpose, and content in order for the teacher candidates to be able to implement this curriculum more successfully and to dominate this curriculum. Because the teachers are the practitioners of science training curricula at schools, it is important that they should be trained with contemporary knowledge, skills, and attitudes and be aware of the new learning and teaching approaches and theories used in science education (Demir et al., 2007). It has been observed that while the education system has a general philosophy, teacher training faculties and institutes do not have a philosophy of education specific to branches but only the general philosophy of the education system (Filiz & Kaya, 2013). It is thought that the final goal should be to find a solution to the concerns about qualification and the central administration should define the standards for the teacher training process and its outcomes. CoHE, rather than defining the standards for the updates in the curricula, sharply identifies all the undergraduate curricula to be applied in the faculties of education and do not give place to flexibility, authenticity, and the attempts to be made for the innovations beyond the minimum limits for qualifications (TEDMEM, 2019).

Although the changes in the science curriculum are not considered sufficient (Özcan et al., 2018; Saraç & Yıldırım, 2019), it is stated that updates are generally made in the science curriculum by considering current world conditions, scientific developments, and political policies (Bahar et al., 2018; Deveci et al., 2018). Until 1998, the training of science teachers in Turkey was conducted exclusively by only two universities, each of which had independently established their own science and teacher training programs (Meriç & Tezcan, 2005). Hence the consistent and systematic results of implementing a national-level program. Over the years, it is seen that theoretical knowledge has become more prominent in teacher training policy. However, teaching, which is a practical profession, should have practical training as well as theoretical knowledge (Çetinkaya et al., 2013).

It has been determined that the science curriculum aims to solve daily life problems with the latest update (MoNE, 2018; Özata Yücel & Kanyılmaz, 2018). However, it has been determined that teacher training programs also address problems away from daily life with intense theoretical knowledge (CoHE, 2018; Yadigaroğlu et al., 2017). The teacher training program should be updated on this issue. Students need to know where in their future lives they can use the knowledge and skills they acquire (Bahar et al., 2018; Muñoz-Campos, Franco-Mariscal, and Blanco-López, 2020). The science curriculum should be organized in a way that supports the professional life of the students and the careers them in this field. Excursions, on-site monitoring, internships and the information about how the tools used are obtained should be available in the science curriculum and become a country policy (Şimşek et al., 2013; Thiry et al., 2017). In addition, professional education at the middle school level (11-15 years) and the indispensable professional branches in the society should be integrated into the curriculum in a very proper way (Rolfsman, 2020; Turan & Kayıkçı, 2019). As a matter of fact, it has been determined that the vocational training students receive during school affects their after-school lives (Hsu et al., 2020).

Turkey has not achieved the expected success in international examinations (Özcan et al., 2018). The indication of it is that Turkey is at the 40th-45th place as a result of the TIMSS and PISA examinations covering science, mathematics, and reading skills. As a matter of fact, according to the 2019 PISA results, it can be said that there has been a slight recovery in science education, and we are above average (MoNE, 2019b). The curricula in Turkey has recently been integrated with daily life problems; however, the measurement and evaluation part of the science curriculum is not sufficient to measure these problems (Balbağ et al., 2018). In general, the theoretical and practical structure of the science teaching curriculum in Turkey does not match with the international examinations (Bayrak & Erden, 2007; Güngör & Bekmezci, 2023; Kuran & Kanatlı, 2009). Considering the ages of the current teachers working for the MoNE, 22.95 % of the teachers are at the age of 30 or below, 38.86 % are between 31-40, 26.29 % are between 41-50, 10.41 % are between 51-60, and 1.48 % is at the age of 61 or above. In general, it can be assumed that older age group teachers received training according to the old teacher training program, learned traditional methods and adopted these methods. Also, it is known that these teachers use traditional measurement and evaluation practices (MoNE, 2019a). For this reason, the science teachers should be allowed to use alternative measurement and evaluation methods, as in the PISA and TIMSS examinations. In addition, educational contents should be selected in accordance with the methods and techniques used in these examinations.

Especially in recent years, great efforts have been made to reveal the teachers' profile (Canado, 2018). In order to train qualified teachers, the education system should be continually evaluated in all aspects, and teachers should always participate in in-service training. The studies carried out in the universities aiming to train qualified teachers should be reshaped according to the changing time and needs, should be up-to-date and scientific, should be equipped with practical techniques and technological infrastructure in accordance with the needs of the new generation (Parlar & Halisdemir, 2020). The reason for it is that the courses in the faculties of education should include the contents such as the research and inquiry of the day, 21st-century skills, and STEM education. In the training of science teachers, the course contents should also be updated considering the expectations of the day and the expectations of the MoNE 2023 vision document.

MoNE points out that they need ninety thousand more teachers besides 1.160.293 working teachers, and they are planning to meet this need within four years (MoNE, 2019a). With the gradual decrease in the need for more teachers, it has been revealed that MoNE should focus on the problems of quality in education rather than the quantity (Anıl, 2009). MoNE has recently been involved in many theoretical-practical in-service training activities to have more qualified teachers. However, these in-service activities are not enough for one million teachers. MoNE, which has a central approach in administration, should organize joint studies with universities to focus on teacher training. Especially with the start of the pandemic process, MoNE has tried to increase the online education opportunities through Informatics Network (EBA). However, online education activities have been negatively affected with the fact that they only include theoretical knowledge, they have been planned to be teacher-centered, the teachers are not all digitally efficient, there is a lack of access for disadvantaged groups, and the internet infrastructure has some problems (Sarı, 2020; Sarı & Nayır, 2020). It is thought that practical applications are not adequate. In addition, the teachers and students who are in the Eastern and South-eastern (disadvantaged) regions of Turkey cannot reach those opportunities (Dönmez, 2020). As can be seen, MoNE and CoHE can solve the current problems by acting in coordination.

Technological developments are increasing rapidly in the world. In addition to groundbreaking inventions in the fields of communication and telecommunication, unmanned aerial vehicles, developments in software fields and increasing interest in robotic coding fields require changes. Interdisciplinary integration, the importance of which has been emphasized intensively since the 2000s, is seen as the fundamental pioneer of industrial and economic development. In addition, global epidemics or disasters emphasize the need to increase protection methods and preventive activities in the health sector. Along with all these, the need for qualified individuals equipped with 21st century skills is included in governments' plans to eliminate future concerns. As can be seen, humanity, which is in a rapid change, has to keep up with the continuity of science and technology. As a matter of fact, science is at the center of all these developments. The development of all of these fields is parallel to the progress in science. For these reasons, science curriculum needs to be updated. They are science teachers who implement the science curriculum. It is unthinkable that teacher training programs cannot be updated in the face of updated curricula. After all, science teachers are the practitioners and communicators of science. In the education of science teachers, they need to be trained with updated training programs on subjects such as technology, innovation, research and development, robotics-coding, interdisciplinary integration, global health problems-prevention and coping with daily life problems. For these reasons, both science teacher training and science curriculum need to be updated in parallel and integrated. In new updates, global problems or targets should be analyzed and reflected together with national expectations. Science teachers are practitioners, communicators and role models of science. A teacher equipped with the requirements of the age can shed light on new generations with a strong curriculum.

Suggestions

CoHE and MoNE should act together about the science curricula and in the training of science teachers. In this context, the faculties of education and public schools should be combined with each other. The reason for it is that education faculties function depending on the universities with legal entities. Although universities are linked to MoNE formally and indirectly, it is thought that the updates on the curriculum by the MoNE are not completely adopted by the faculties. Therefore, the faculties of education, the schools and the units that update the curriculum should be directed by the same institution particularly for the field of science.

The framework of formal education in science curricula, there should also be educational activities such as the ones including science museums, art events and excursions.

Teachers, students and parents should be encouraged in this regard. Similarly, the holidays in the academic period should be supplied with the activities that can allow students and teachers to both rest and learn.

In the current CoHE science teacher training program, there are only laboratory practices in two semesters. The development of science laboratories in schools should be increased by increasing laboratory practices and integrating them into the science curriculum (Especially due to the danger of chemicals, chemicals in all laboratories were confiscated).

The curriculum's especially international measurement and evaluation dimensions such as PISA and TIMSS should be kept alive, and brochures and educational activities should be developed according to it.

A sustainable curriculum integrated with the state policy should be developed in accordance with the views of teachers, students and parents. Activities should be planned in a way that students can discover their own interests and abilities.

Knowledge of field, professional knowledge and knowledge of general culture should be provided for the teachers in the schools, and they should be renewed within the framework of the updated curricula.

Compliance with Ethical Standards

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CRediT author statement

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Research involving Human Participants and/or Animals

No data were obtained from human or animal subjects in this study. Data was collected only through document analysis. Therefore, ethical permission was not obtained.

Türkiye'de Fen Bilimleri Dersi Öğretim Programları ve Fen Bilimleri Öğretmeni Yetiştirme: Dünü, Bugünü ve Geleceği

Özet:

Bu makale, Türkiye'deki fen bilimleri dersi öğretim programları ve fen bilimleri eğitimi programlarındaki zorlukların altını çizmektedir. Ayrıca hem bu zorluklar hem de mevcut fırsatlar öğretmenler, eğitimciler ve politika yapıcılar için analiz edilmektedir. Bu literatür taramasının amacı Türkiye'de fen bilimleri dersi öğretim programının tarihsel gelişimini ve fen bilimleri öğretmeni yetiştirmeye yönelik politikaları belirtmektir. Bu araştırma kapsamında 2005 öncesi, 2005, 2013 ve 2018 yılı fen bilimleri dersi öğretim programları ihtiyaçlar, beklentiler ve program çıktıları açısından analiz edilmiştir. Türkiye'deki fen bilimleri öğretmeni yetiştirme programlarının gelişim süreci (1998, 2007 ve 2018) değerlendirilerek gelecekte olası program değişiklikleri tartışılmıştır. Programların zaman içerisinde çağın standartlarına uygun olarak güncellendiği bulgulardan anlaşılmaktadır. Ancak öğretmen yetiştirme programlarının güncellemelere ayak uyduramadığı, bunun da eğitimin kalitesi, uluslararası sınavlar gibi farklı aşamalarda pek çok soruna yol açtığı gözlemlenmiştir. Bu literatür taramasında, eğitim uygulamalarından ve özellikle öğretim programlarının hazırlanmasından sorumlu Milli Eğitim Bakanlığı ile öğretmen yetiştirme politikalarından sorumlu Yükseköğretim Kurulu arasındaki koordinasyona yönelik öneriler sunulmuştur.

Anahtar kelimeler: Fen bilimleri dersi öğretim programı, Öğretmen eğitimi, Fen bilimleri eğitimi, Türkiye.

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Research Article

How do Middle School Students Use Their Knowledge of Geometric Area Measurement When Determining Fractions?

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Abstract – In this study, the objective was to assess students' proficiency in utilizing their knowledge of geometric area measurement and fractions, and to examine how they apply this knowledge in determining fractions. The research, structured as a case study, encompassed nine students from the 6th, 7th, and 8th grades. Data gathered through individual interviews were analyzed using content analysis. The findings revealed that participants predominantly exhibited a preliminary internalization profile in terms of their understanding of fractions and area measurement. This profile encompasses stages such as pre-internalization, internalization, condensation, and reification. It was observed that students employed diverse strategies and methods within various segmented fraction area models, thereby unveiling distinct mental schemes. The responses provided by students to the tasks illustrated their comprehension of fractions and area measurement. Based on the research results, it is recommended that mathematics teachers and classroom instructors, tasked with imparting crucial concepts like fractions, devise tasks that integrate fundamental mathematical principles and establish connections across different domains.

Key words: Fraction, Area Measurement, Middle School Students.

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Introduction

The concept of fractions is inherently developmental, and it is believed that students require significant experience and time to grasp this concept thoroughly (Van de Walle et al., 2013). It is underscored that fractions hold a crucial place in mathematics education, and as students comprehend the concept of fractions, they also lay the groundwork for mathematical success in later stages (Bailey et al., 2012). Siegler et al. (2013) asserted that fraction instruction should be enhanced, highlighting that the competencies associated with fractions constitute a fundamental skill that must be cultivated in students. The importance and difficulty of teaching fractions were emphasized, given that fractions lack a singular structure, consist of interconnected sub-structures, and possess various meanings such as part-whole, division, measurement, operator, and ratio meanings (Kieren, 1976). Despite these challenges, numerous studies suggest the effective use of visuals and models in the teaching of fractions, making the concept more accessible (Cramer & Henry, 2002; Siebert & Gaskin, 2006; Doğan Temur, 2011; Van de Walle et al., 2013). Cramer et al. (2010) argued that models serve as essential tools, allowing students to experience fractions in real-world contexts. Among the models employed for fraction representation is the area model (Van de Walle et al., 2013), illustrating how fractions constitute a part of an area or the relationship of a region to the whole. As the area model aligns with concepts of division and equal sharing, it is deemed a valuable starting point for introducing fractions (Van de Walle et al., 2013). However, some researchers have noted the oversight in emphasizing that fractional parts should be of the same size in field models, neglecting the recognition that parts do not necessarily need to be identical (Lee & Lee, 2020; Van de Walle et al., 2013), leading to a limited understanding of the area model (Van de Walle et al., 2013; Zeybek & Cross Francis, 2017). According to certain researchers (Lee & Lee, 2020; Lee & Hackenberg, 2014; Olive & Steffe, 2010), comprehending the area models of fractions not only facilitates a robust understanding of fractions but also enhances understanding of concepts in geometric measurement and their interconnectedness across various mathematical domains. In this regard, it can be asserted that grasping the area model of fractions is of paramount importance for students.

Similar to the concept of fractions, the principles and competencies associated with area measurement encompass fundamental knowledge and skills essential for students in their daily lives (Gürefe, 2018). Research has demonstrated that although students may be acquainted with the area formula, they encounter challenges in measuring area and struggle to apply the formula to given situations (Chappell & Thompson, 1999; Tan Şişman & Aksu, 2009). This difficulty arises because students are often taught formulas through procedural calculations without a thorough understanding of how and why these formulas are employed (Kordaki & Balomenou, 2006). Therefore, it is imperative to develop a robust comprehension of the concept of area measurement. Indeed, the concept of area measurement serves as a foundational prerequisite for numerous other subjects and significantly influences students' comprehension of various mathematical domains (Cavanagh, 2008). Given that the conceptual understanding of area measurement is believed to encompass knowledge of area measurement strategies, it is crucial to assess students' conceptual grasp of this concept, as it is indicative of their high-level thinking abilities (Lehrer et al., 2003).

Upon reviewing the literature, numerous researchers (Hackenberg & Lee, 2015; Lee, 2017; Lee & Hackenberg, 2014; Steffe & Olive, 2010; Van de Walle et al., 2013) have asserted that teaching fractions through a measurement-based approach contributes to a more meaningful understanding of fractions as quantities. For instance, the measurement interpretation of fractions offers a natural context for introducing complex fractions and aids students in quantitatively evaluating fractions (Hackenberg & Lee, 2015; Lee, 2017; Steffe & Olive, 2010; Van de Walle, 2013). Additionally, Mitchell (2011) established a relationship between measurement and fractions in his research, focusing on length and area models of fractions. He found that students utilize fractional knowledge and geometric area measurement knowledge concurrently when solving problems related to area models. While Mitchell's (2011) research illuminates how the interpretation of measurement can be beneficial in teaching fraction concepts, it also underscores the limitations of a part-whole interpretation in fractions. In this study, students were tasked with solving problems involving atypically partitioned area models and expressing the strategies and reasoning they employed in this process. The aim was to scrutinize students' knowledge and reasoning regarding the area model of fractions by altering the typical representations of these models—specifically, by questioning how many fractions of different shapes in the area models could be identified when presented in an unconventional manner. Some studies (Kavuncu, 2019; Toptaş et al., 2017; Yakar, 2019; Yavuz Mumcu, 2018) have been conducted on how to utilize various models, such as length, cluster, and area models, when representing fractions. In contrast to those studies, this study reveals how the area model is employed in determining fractions, the level of knowledge related to fractions and area measurements, and the students' learning status regarding the subject by considering these knowledge levels collectively.

Conceptual Framework

Sfard (1991) presents a theoretical framework for acquiring mathematical concepts and asserts that the capability to perceive a number or function as both a process and an object is essential for achieving a profound understanding of mathematics, regardless of the concept's definition. Sfard distinguishes between operational and structural understandings of a mathematical concept. A student with operational understanding comprehends how a concept operates through algorithms, processes, and actions. On the other hand, structural understanding involves recognizing the concept as a mathematical object. While structural understanding is immediate, static, and integrative, operational understanding is dynamic, sequential, and detailed (Sfard, 1991). Sfard suggests that operational understanding should precede structural understanding, proposing a progression from working with physical models to using pictorial representations and eventually dealing solely with symbols. According to Sfard (1991), the transition from operational to structural understanding occurs in three stages: internalization, condensation, and reification. In the internalization phase, students engage with familiar objects and processes that lead to a new concept, internalizing the process through mental representations. At this stage, the process no longer requires physical execution but can be considered, analyzed, and compared mentally. An example is a student becoming adept at subtracting negative numbers. The condensation phase involves compacting long sequences of transactions into more manageable units, enabling students to think about a particular process as a whole without delving into details. Progress in condensation facilitates the ease of switching between different representations of the concept. For instance, in the context of negative numbers, this stage is where a student becomes proficient in arithmetic operations involving negative and positive numbers. The reification stage allows students to perceive the concept as a complete object, solve problems containing all examples meeting a certain condition, and initiate the internalization of higher-level concepts. For example, at this stage, in the case of negative numbers, a student can treat them as a subset of the ring of integers. As students' progress from internalization to condensation, the redoing phase marks a significant advancement. Repetition, defined as a change, is the ability to see something familiar in a completely new light (Dougherty & Slovin, 2004). The continuous nature of Sfard's concept formation process provides a framework for observing students' ability to connect geometric measurement knowledge and fractional knowledge (Lee & Lee, 2020). When students calculate the area of each piece, they consider crucial features of the fractional area model, such as equal partitioning, the whole, and the piece-whole relationship. Therefore, utilizing these understandings across multiple fields of mathematics and coordinating them is expected to yield rich data.

Lee and Lee (2020) have extended Sfard's (1991) theory by introducing a pre-internalization stage and applied this model to assess students' understanding of geometric measurement in problems involving area models of fractions. In the pre-internalization stage, as described by Lee and Lee (2020), students do not recognize the geometric measurement unit and become aware that the area or length to be measured is a quantity. They may lack awareness of the relationship between co-partition and part-whole in fractions, or if they express it, it is with limited understanding. Lee and Lee (2020) have outlined four profiles representing different stages in this model, incorporating area measurement from geometric measurement:

Profile 1 (Pre-internalization): This profile indicates that students struggle to understand both fractions and area measurement. The levels in this profile are as follows:

- area measurement level 0 and fraction knowledge level 0,

- area measurement level 1 and fraction knowledge level 1 or

-area measurement level 0 and fraction knowledge level 1

Profile 2 (Internalization): This profile illustrates students' limited understanding of both area measurement and fractions. The levels in this profile are as follows:

-area measurement level 2 and fraction knowledge level 2

Profile 3 (Condensation): This profile demonstrates that students have a solid understanding of fractions but a limited understanding of area measurement knowledge. The levels in this profile are as follows:

-area measurement level 2 and fraction level 3

Profile 4 (Reification): This profile signifies that students possess a solid understanding of both area measurement and fractions. The levels in this profile are as follows:

-area measurement level 3 and fraction level 3

The explanations for the levels specified in the profiles, regarding fractions and area measurement, are as follows:

Four levels have been determined for fraction knowledge. At Level 0, the student is unaware of the concept of the whole and equal parts. In other words, they do not recognize that fractions involve equal division, and they cannot represent the whole. At Level 1, the student is aware of equal partitioning but with limited understanding. They can express equal partitioning but with constraints. For instance, they might require shapes to be congruent, insist on an equal number of points in the three parts, or stipulate that two parts must appear larger than the other part. At Level 2, the student understands equal partitioning without referencing the part-whole relationship. They compare the number of unit squares without considering the area of the whole and its relationship to each part of the area. At Level 3, the student comprehensively understands the amount of the whole, equal division, and the relationship between the parts and the whole. They have a holistic understanding of fractions, encompassing the entire quantity, the equal division of that quantity, and the interconnection between the parts and the whole.

The four levels for field knowledge in area measurement have been delineated. At Level 0, the student does not recognize the area unit. For instance, a student at this stage can only count the number of dots within a given shape on a grid sheet without specifying the unit of area. At Level 1, the student is aware that area is the amount of a surface, but they do not specify the unit of area. At Level 2, the student recognizes the area unit, but they count partial units based on guesswork, showcasing uncomplicated spatial reasoning. The student is aware of area conservation; for example, they calculate the area measure by counting the number of unit squares in each piece, considering the whole square, and then combining the piece squares based on estimation. At Level 3, the student comprehensively understands that applied geometric features are associated with the numerical structure. For instance, the student can count unit squares by combining partial squares using methods such as the cut-out method or the take-away method.

By utilizing these profiles, the aim is to unveil students' ability to employ their knowledge of geometric area measurement and fraction knowledge, as well as to observe how they apply their knowledge of area measurement in determining fractions.

Method

Research Model

This study was structured as a case study, aiming to investigate students' proficiency in utilizing geometric area measurement knowledge and fraction knowledge. In case studies, the researcher delves into one or more situations in detail over a specific period (Creswell, 2007). The focus lies in exploring the understanding derived from the situation rather than making broad generalizations (Denzin & Lincoln, 2011). In this research, the responses provided by students to questions regarding the area models of fractions were considered as the situation, and these responses were further elucidated through additional questions during the interviews. As the study involved an in-depth examination of more than one sub-case and unit, a nested single case design was employed (Yıldırım & Şimşek, 2006). Within the research framework, student answers to questions prepared with reference to Lee and Lee's (2020) categories and Sfard's (1991) theory were assessed as the situation.

Participants

The research participants consist of a total of 9 students, with 3 students each from the 6th, 7th, and 8th grades attending a public school in the fall semester of the 2021-2022 academic year. The students' achievement levels were categorized as good, medium, and low for each grade level, considering factors such as school report grades and teachers' opinions to assess their success. Participants were assigned code names such as G-S1, M-S2, L-S3, where G represents good level, M represents medium level, L represents low level, and S denotes student. Among the participants, students coded G-S1, M-S2, L-S3 are in the 8th grade, students with code G-S4, M-S5, L-S6 are in the 7th grade, and students with code G-S7, M-S8, L-S9 are in the 6th grade. Teacher opinions played a crucial role in the selection of participants, considering students who had a background in the subject under investigation, either through classroom instruction or private lessons. The selection process prioritized students with prior exposure to the relevant topic. All participating students signed a consent form indicating their willingness to participate in the study.

Data Collection Tool and Process

The research data were gathered through one-to-one interviews and document analysis. Shapes and operations drawn by the students on paper during the research constituted the documents examined. These shapes and processes were documented by taking photos. To design questions that assess students' ability to connect geometric measurement knowledge and fraction knowledge, a literature review was conducted.

Questions were formulated, drawing inspiration from Lee and Lee's (2020) study, specifically focusing on area model questions that were typically unpartitioned. These questions contained parts with identical areas but were not compatible with each other. The intent was to explore the part-whole relationship for fractions and equal partitioning, while also integrating fundamental concepts such as attribute, addictiveness, and units in measurement. For instance, questions were created by presenting rectangular shapes divided into pieces to be expressed as the compound fraction 4/3 and asking students to identify the fraction represented by the shape as well as expressing each piece as part of the whole fraction.

While formulating questions, attention was given to using different geometric shapes, such as area models of a triangle (Question 1-Q1), square (Question 2-Q2), rectangle (Question 3-Q3), and nested squares (Question 4-Q4), which were not typically segmented. Additionally, various types of fractions, including simple fractions, compound fractions, and integer fractions, were incorporated into the questions. To ensure content validity, the questions were reviewed by three mathematics education experts, and adjustments were made accordingly. Some questions from the initial pool were excluded as they were deemed inappropriate for the students' level or the study's objectives. The final questionnaire used in the study consisted of 4 questions. To determine the reliability of the test, a pilot study was conducted with 4 students before the main application. The prepared questions were administered to the students in two sessions through one-on-one interviews, each lasting 30 minutes. To address potential boredom and distraction, the interviews were kept within a reasonable time frame. The sessions were recorded using a video camera for subsequent analysis.

Data analysis

During the data analysis process, video recordings of the interviews with students were transcribed, and the students' responses were systematically documented in a Word file along with accompanying photographs. The analysis was conducted by considering the levels established by Lee and Lee (2020) according to Sfard's theory. The answers were categorized into profiles that align with these levels. In light of the students' responses, the levels for both the area and fraction questions (Level 0, Level 1, Level 2, and Level 3) were determined, and based on these levels, the students' profiles (Profile 1, Profile 2, Profile 3, and Profile 4) were identified.

To ensure the reliability of the coding during data analysis, the data were independently reviewed by a different expert than the researchers. The consistency of coding between a researcher and the expert was established at 90%. In instances where discrepancies arose, discussions were held to reach a consensus, achieving 100% agreement on the data. This process helped enhance the overall reliability of the analysis.

Ethics Committee Decision

Ethics committee approval was obtained for this research with the decision of the Social and Human Scientific Research and Publication Ethics Committee of Uşak University, dated 09/09/21 and numbered 2021-168.

Results

In the analysis of data pertaining to students' proficiency in utilizing geometric area measurement knowledge and fraction knowledge, four main themes were identified. These themes corresponded to the profiles established in the study: Profile 1 (Pre-internalization), Profile 2 (Internalization), Profile 3 (Condensation), and Profile 4 (Reconstruction). Furthermore, the table includes information on the specific profiles each student exhibited in response to particular questions. The participants' profiles are detailed in Table 1.

Table 1 Information about Profiles of the Participants

Profiles	Questions	Students
Profile 1 (pre-internalization)	Q1, Q2, Q3, Q4	L-S3 (8th grade), boy
	Q1, Q2, Q3, Q4	M-S5 (7th grade), boy
	Q1, Q2, Q3, Q4	L-S6 (7th grade), boy
	Q1, Q2	M-S8 (6th grade), girl
	Q1, Q2, Q3, Q4	L-S9 (6th grade), boy
Profile 2 (internalization)	Q3	M-S8 (6th grade), girl
Profile 3 (condensation)	Q1, Q2, Q3	G-S7 (6th grade), boy
Profile 4 (reification)	Q1, Q2, Q3, Q4	G-S1 (8th grade), boy
	Q1, Q2, Q3, Q4	M-S2 (8th grade), boy
	Q1, Q2, Q3, Q4	G-S4 (7th grade), girl
	Q4	G-S7 (6th grade), boy
	Q4	M-S8 (6th grade), girl

As indicated in Table 1, the responses provided by students to the area model questions exhibited variations based on the question type or the students' subject knowledge. Consequently, the same student may have been classified into different categories across distinct questions. Notably, students with lower success levels tended to consistently fall within Profile 1 and 2 across all questions. Conversely, students with medium and high success levels predominantly demonstrated proficiency at Profile 3 and 4 across all four questions. Below are detailed presentations of students' fraction knowledge and area measurement knowledge levels within each category.

Findings Related to Profile 1 (Pre-internalization)

Students in Profile 1 (Pre-internalization) exhibited fraction knowledge levels and area measurement knowledge levels ranging between 0 and 1. At this level, it is evident that these students lack an understanding of the part-whole relationship and co-dividing in fraction knowledge. Moreover, they are aware of area as a quantity in area measurement, but they do not possess knowledge of the area measurement unit. These characteristics indicate that students in this category face challenges in grasping fractions and measuring area. During data analysis, several subcategories emerged under the theme of Profile 1 (Pre-internalization), including Counting Intervals, Counting Points, Counting the Number of Sides of the Shape, and Making Decisions Based on the Appearance of the Shape. These subcategories further elucidate the specific challenges and limitations observed in students classified under Profile 1.

Counting Dot

In this category, it was observed that students did not recognize the area unit and resorted to counting points within the figure, including points on the edges, inner regions, or line segments. The area measurement knowledge of these students, who relied on a point-counting approach, was categorized as level 0, and their fraction knowledge varied between level 0 and level 1. Specifically, among the seventh and eighth-grade students coded as L-S3, M-S5, and L-S6, a tendency to count points was noted. For L-S3, the student counted points on the edges in rectangular and square area model questions, while focusing on points in the inner region for triangular area model questions. Contrary to L-S3, M-S5 counted points on the side lengths of the parts in all shapes presented in the area model questions. On the other hand, L-S6 counted points on the longest line identified in some questions and points on the line segments outside the parts within the figures in other questions. Additionally, L-S6 tended to count points above the side lengths while determining the area. In expressing fractions, this student used the statement "When two of the four parts are equal, it means 2/4, and when all three are equal, it means 3/4," without considering the concepts of the whole and equal division. The drawings made by L-S6 and their corresponding dialogue are provided in Figure 1.

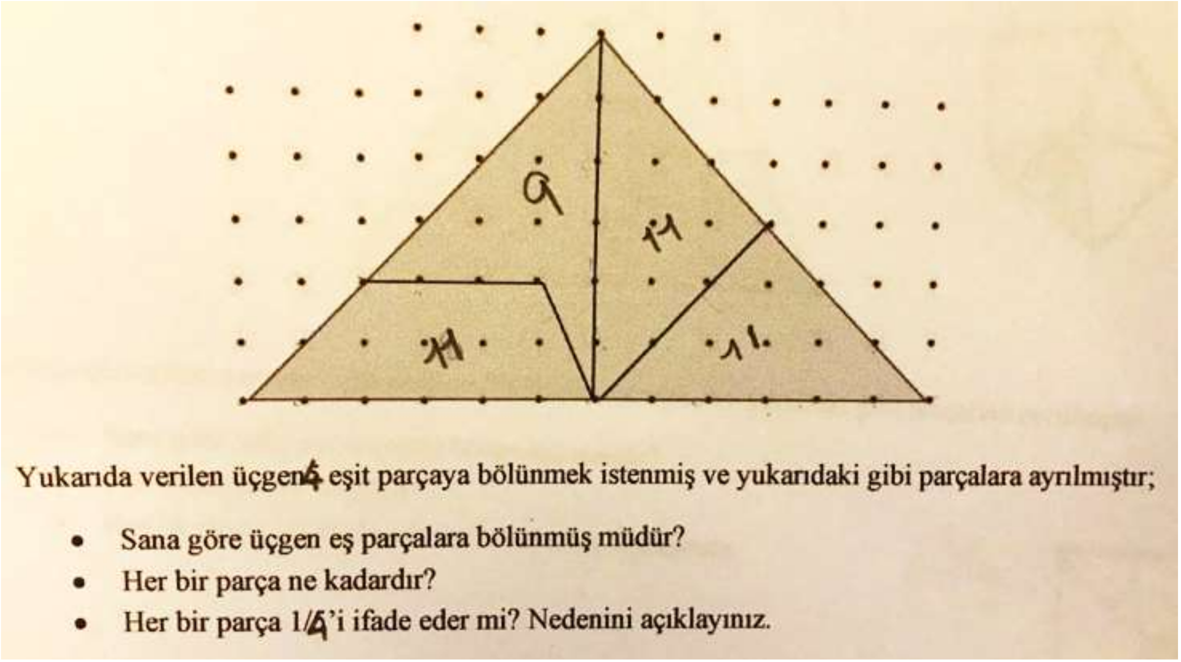

Figure 1 The Answer Of L-S6 Coded Student

L-S6: 1,2,3,4,5,6,7,8.

Researcher: What did you count?

L-S6: I count the sides. (Again, counting the dots on the outer edges of the parts)

L-S6: None 11.

Researcher: Why did you change what happened? What are you counting now?

L-S6: I counted the sides. (This time he counted the points on all side lengths with perimeter logic)

L-S6: Here is 9, here is 11, here is 11.

L-S6: Is it divided into equal parts? It is not divided. 3 out of 4 equal parts.

Researcher: You said 3 out of 4 are equal parts. Is it true?

L-S6: Yes, we say 3/4 for this fraction.

Researcher: Why did you say that?

L-S6: When 3 of them are equal, it becomes 3/4.

Researcher: Well, do these pieces represent 1/4?

L-S6: No, it's not 1/4. It is 3/4. Three pieces are equal.

It was observed that the area measurement level of the student coded as L-S6 in this question was determined to be 0. In this particular question, the student did not recognize the unit of area measurement and instead counted the number of points on the side lengths of the shape. Furthermore, the student struggled to articulate how the whole and congruent division actually occurred, only stating that three of the four parts in Figure 1 were equal to each other and the fraction was thus 3/4. Consequently, it was evident that the student's fraction knowledge level was 0.

Counting the Number of Sides of a Shape

In the category, it was observed that students counted the number of sides of the shape without recognizing the area unit. The area measurement knowledge of students utilizing this counting process was categorized as level 0, and their fraction knowledge varied between level 0 and level 1. While only the student coded as L-S3 was categorized under counting points in other questions, they appeared in the category of counting the number of sides in the integer fraction question (See Figure 2). This student asserted that since the shape is not equal, it would not represent a fraction. The following dialogue occurred with the student coded as L-S3.

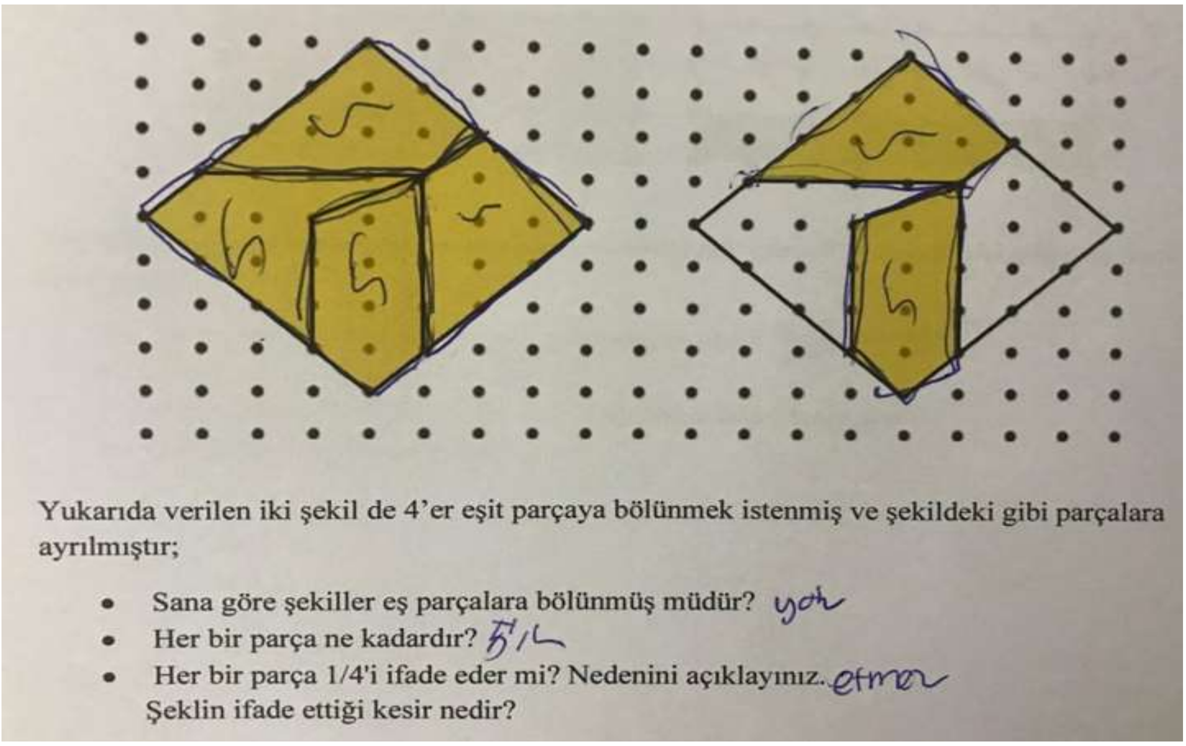

Figure 2 The Answer of L-S3 Coded Student

L-S3: Let's count the lines.

Researcher: Why did you count the lines?

L-S3: We find the inside of the figure.

Researcher: Are you counting the lines while you find the inside of the shape?

L-S3: We find the area.

Researcher: Is this how we calculate the area of a shape?

L-S3: Yes.

Researcher: Okay, let's see.

L-S3: 1, 2, 3, 4, 5;1, 2, 3, 4, 5;1, 2, 3, 4;1, 2, 3, 4, 5 (counting how many sides the pieces have) Is it broken into pieces? No, it is not divided.

Researcher: How much is each piece?

L-S3: 5 and 4.

Researcher: Does each piece represent ¼?

L-S3: Not equal.

Researcher: What fraction does the figure represent?

L-S3: It does not mean fraction.

Researcher: You don't answer the last question because it doesn't express a fraction?

L-S3: Yes.

For the student coded as L-S3, it was found that their area measurement level was 0, and their fraction knowledge level was 1. While the student did not recognize the unit of area and counted points in all questions except this one, they adopted a different method by counting the number of sides of the figure in the integer fraction question. The area measurement level of the student, who claimed to calculate the area by counting the number of sides, was determined to be 0. Furthermore, it was observed that the student's knowledge of fractions was at level 1, indicating an awareness of equal division with limited understanding. The student stated that the number of sides of the given four pieces should be equal but struggled to express the fraction. In this context, it can be inferred that the student has a limited understanding when articulating the division of fractions.

Interval Counting

In this category, students failed to recognize the area unit and attempted to determine the area by counting the distances between points on the edges of the shape. It was observed that the geometric area measurement knowledge level of students employing this interval counting process was 0, and their fraction knowledge level was 0 or 1.

Students coded as M-S8 and L-S9 exemplified this behavior by counting intervals on the edges of the area. For instance, L-S9 determined the side lengths of the shapes provided in the figure (See Figure 3) and endeavored to identify equal parts with precisely the same side lengths. The dialogue with the student coded as L-S9 is presented below:

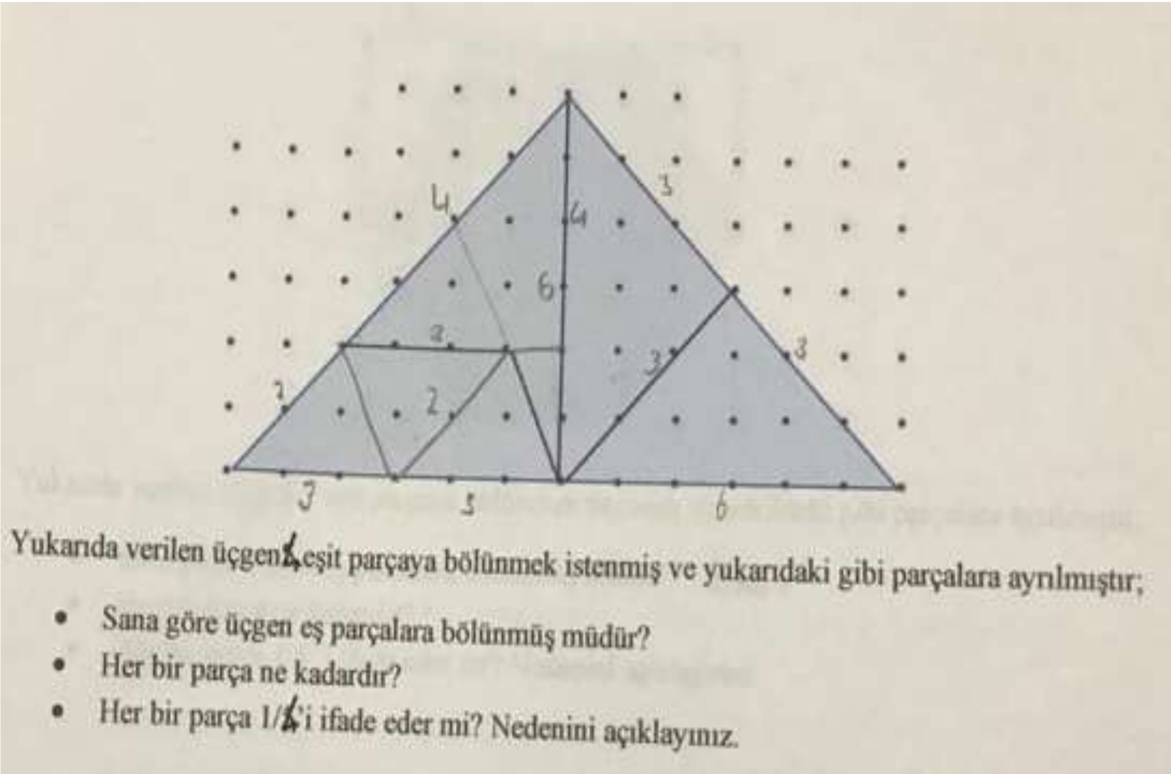

Figure 3 The Answer of the Student Coded L-S9

L-S9: He said, "Is the triangle divided into equal parts according to you?" First we need to add the following sides of a triangle. If we count them as one unit, the long place at the bottom is 6 units and each side is 3 units. This is a complete triangle (meaning the rightmost triangle)

Researcher: What do you say you need to collect?

L-S9:…(Goes to the other triangle-shaped piece), the long side of this is 6 units and the short sides are 3.3. Then these are equal triangles. Now what makes the most sense to me is to make them a whole piece. We draw a line through (dividing the quadrilaterals into triangles)

L-S9: We made a triangle with 4 sides and 4 sides. If my calculation is correct, this is a triangle with all sides 4. If we make a triangle here, there remains a piece, how can we handle it?

Researcher: Well, what are we calculating here, I don't understand, what use will these triangles you divide serve us?

L-S9: These triangles were not equal.

Researcher: Should it be in the form of 3.3.6 units to be equal?

L-S9: It doesn't need to be equal.

L-S9: Actually, if we draw a line from here, we will complete a triangle here as well, and its two down sides will be 3 units.

L-S9: We divided it into 4 equal parts, but we still have these parts.

Researcher: Did you divide the quadrilateral pieces equally?

L-S9: As a result, the parts are not equal and do not represent ¼.

Researcher: How do you decide with the triangles you separate inside the quadrilaterals that they are not equal?

L-S9: It should have been 3,3,6, it didn't happen, the triangles are not equal, that's why.

L-S9, coded as a student, was observed not to recognize the unit of measurement for the area. In an attempt to achieve triangles with the same side lengths for fraction equality, and failing to obtain these triangles, the student asserted that each part was not equal. While there was some awareness of the concept of equality in fractions, it appeared to be limited, and the student's knowledge of fractions was categorized at level 1, indicating a lack of understanding of which parts should be congruent and how.

Deciding Based on the Appearance of the Shape

In this category, the students did not recognize the area unit and opted to calculate the area based on the shape's appearance (whether it appeared large or small, etc.). Students with the codes M-S5 and L-S6, who were in the seventh grade, provided responses falling within this category. These students attempted to determine the area solely based on the appearance of the figure, avoiding calculations for shapes they deemed difficult or different. In the frame question presented (Figure 4), both students stated that the frame decreases in size from the outside to the inside, implying that its area also diminishes. Student M-S5 asserted that the parts in fractions cannot be equal because they decrease in size, demonstrating limited awareness of division and participating in the knowledge of fractions at level 1. Conversely, student L-S6 claimed that each part would represent 1/3 because the figure is divided into three parts. Their explanation suggested a lack of awareness of fraction division, placing them at level 0 in terms of fractions.

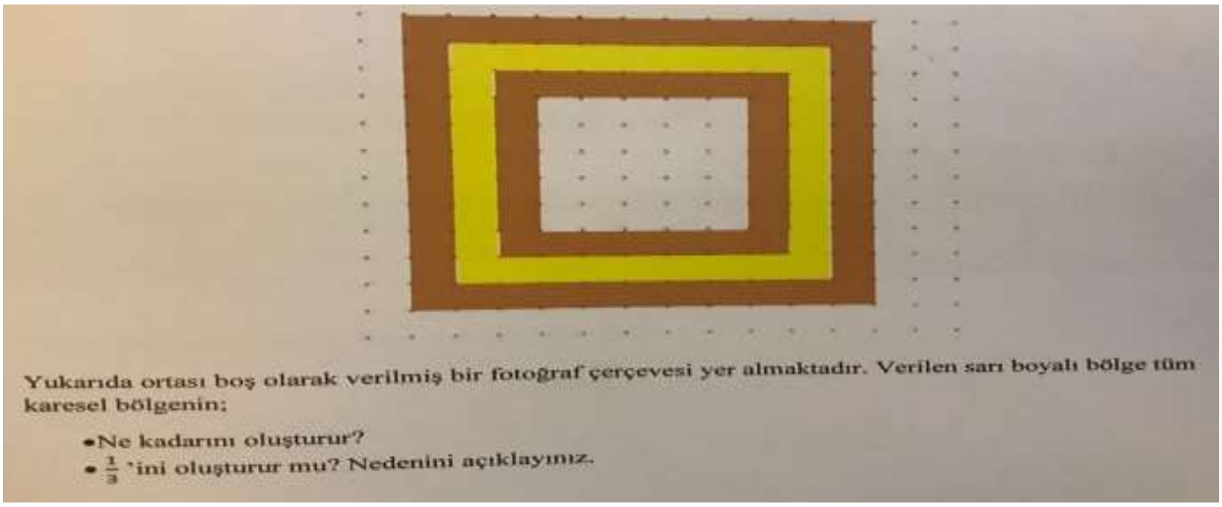

Figure 4 The Question Asked to the L-S6 Coded Student

Findings Regarding Profile 2 (Internalization)

Students in this category recognized the area unit, counted the unit squares in the figure, and combined the partial squares as an approximation. However, in fractions, they only compared the number of unit squares without paying attention to the relationship between the part and the whole. It was determined that the knowledge of fractions and geometric area measurement of the students in this category were at level 2. Only M-S8, who was in the sixth grade, provided answers in this category. While this student was in the point counting category of Profile 1 in all other questions, she expressed the area of the rectangle in the area model questions containing rectangular pieces as the vertical and horizontal area (in terms of width and height). In the area model questions with triangular parts, she created a rectangular shape by combining the triangles and expressed the area covered by the rectangle as the area it occupies vertically and horizontally (in terms of width and height). She stated that these rectangular pieces she found were equal to each other and represented fractions, but she referred to equipartition without explaining the part-whole relationship in fractions. An example dialogue of M-S8, who gave answers in this category, is presented below:

M-S8:1 right here. This is 1, 2, 3, 4, 5, 6, 7. Seven times 7 is here.

Researcher: Why did you multiply there?

M-S8: I found the area of the rectangle.

Researcher: You didn't calculate the area in the previous question, but never. You counted the range. Why did you calculate the area in this one?

M-S8: Because I know the area of the rectangle, I do not know the others. I didn't calculate because I couldn't find the area of those shapes.

Researcher: So how do you calculate the area of these top pieces?

M-T8: Except for that, this is actually the rectangle. But I don't know how to find this triangle either. Although here (showing the sides of the triangle he drew) he went two units up and one unit to the side. Here, too (he shows the congruent triangle next to the triangle he drew), two units go up and one unit to the side, and they are equal to each other.

Researcher: So how much is each piece?

M-S8: 7 units

Researcher: You said the triangles must be equal, but did you find out how many parts are 7?

M-S8: Hmm, all of this (showing the white part) is 7 times 2 out of 14, since they are equal, each of them becomes 7.

M-T8: 3 means one and the value of 1 is exactly 1/3.

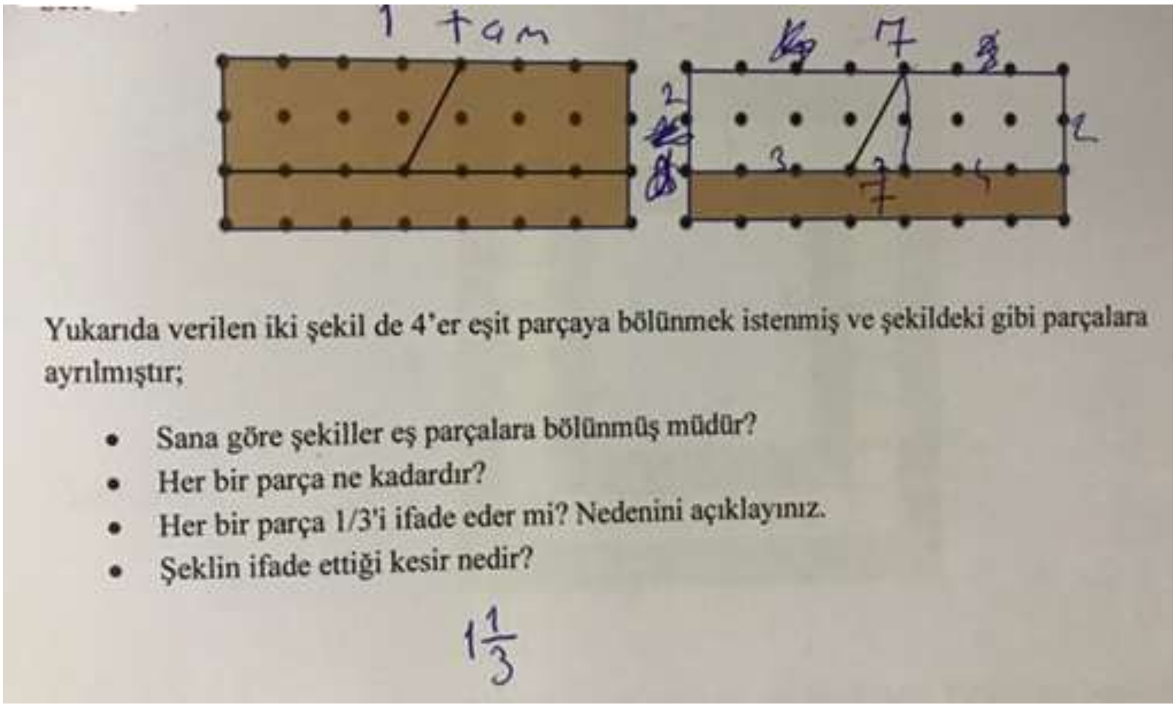

Figure 5 The Answer of the Student Coded Profile 2-M-S8

The student coded as M-S8 expressed the area of the unshaded rectangle at the top as "7 times 2 equals 14". The area of the shaded rectangle below was calculated with the formula "7 times 1 equals 7". However, she stated that she did not know how to calculate the area of the triangle, and by looking at the side lengths of the triangular regions, she decided that the parts were the same and determined that all parts were equal by saying "half of 14 is 7". Therefore, it was seen that the student's knowledge of geometric area measurement was at level 2. In addition, she determined that the parts were equal without referring to the part-whole relationship in the knowledge of fractions, and she provided information showing that the fraction was at level 2 by saying "1 represents 1/3 of the whole".

Findings Regarding Profile 3 (Condensation)

Students in this category recognized the area unit, counted the number of square units in each piece to calculate the area, and combined the partial units as an approximation. In fractions, students determined equal partitioning, the amount of the whole, and the part-whole relationship. Geometric area measurement knowledge of the students in this category is expressed as level 2, and fraction knowledge level is 3. This category shows that students understand fractions but have limited understanding of measuring area. Only students with the code G-S7 were included in this profile. Except for the G-S7 coded student frame question, all other area questions took place at profile 3 level. The student with the code G-S7 counted the unit squares in most of the questions and combined the partial units. After dividing the parts into unit squares (See Figure 6.), he counted the complete unit squares, and combined the incomplete unit squares as larger than half and smaller than half. The drawing and dialogues of the student with the code G-S7 were as follows:

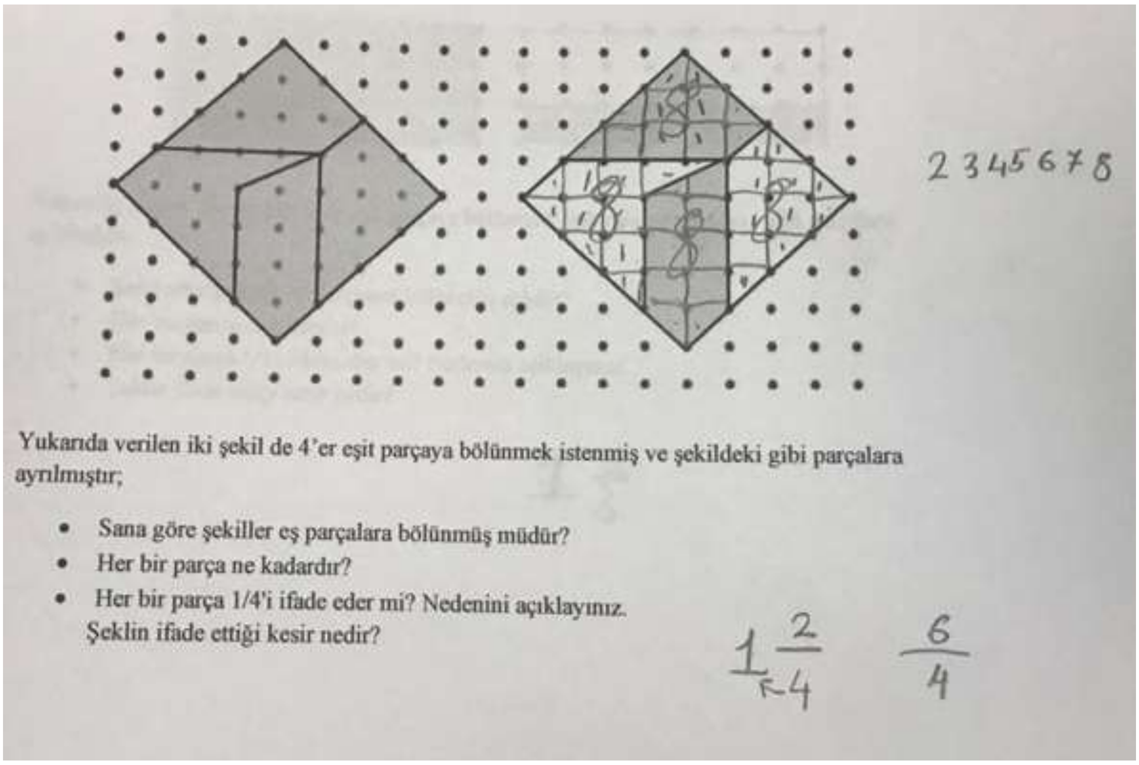

Figure 6 The Answer of The Student With The Code G-S7

G-S7: What is the area of this place? We need to find it. 1,2,3,4,5 here was half 6. It was 7 and 8.

G-S7: This place is also 8.

Researcher: How did it become 8?

G-S7: One of these two pieces is understood to be larger than half, and the other is smaller than half. When combined, it becomes one.

G-S7: This place is 1,2,3,4,5,6,7 and when combined with this, it became 8 units.

G-S7: 1,2,3,4,5,6 came out here and here, and this came out as 8.

Researcher: And is the figure divided into equal parts?

G-S7: Yes, each of them was 8 square units.

Researcher: Do the parts mean ¼?

G-S7: Yes, it will.

Researcher: So what does this figure represent as a fraction?

G-S7: 1 full 2 quarters (1 full 2/4)

Researcher: How else can we express this fraction?

G-S7: Compound fraction is also possible. It happens at 6/4.

The student with the code G-S7 stated, *"One of these two pieces is perceived as larger than half, and the other is smaller than half. When you combine them, it forms a whole."*. He inclined to aggregate partial units using expressions as they are. He counted the number of unit squares in each piece, considering the entire square, and combined the piece squares based on estimation. Asserting that each piece consisted of 8 unit squares and was equal, he conveyed an understanding of equal division and the relationship between the parts and the whole.

Findings Regarding Profile 4 (Reification)

The students in this category exhibit a comprehensive understanding, recognizing the unit of area, associating applied geometric features with numerical structures, and demonstrating proficiency in determining the whole amount in fractions, equal division, and the relationship between parts and the whole. Both area measurement knowledge and fraction knowledge levels of students in this category are expressed as 3, signifying a thorough comprehension of both fractions and area measurement. Within this category, students showcase diverse approaches such as parsing the shape and employing formulas, combining parts, counting unit squares, and determining area by completing the shape. Students with the codes G-S1, M-S2, G-S4, G-S7, and M-S8 provided responses that align with this category.

For instance, the student coded G-S1 consistently demonstrated a Profile 4 level in all area-related questions. During area calculations, this student effectively decomposed geometric shapes, calculated the area of the created parts using formulas, and demonstrated the ability to determine the whole amount, establish equal partitioning, and articulate the relationship between the part and the whole.

The student with the code M-S2 consistently demonstrated a Profile 4 level in all questions related to the area model. In the process of area calculation, the student effectively divided the shape into parts and applied area calculation methods using formulas. In instances where challenges arose in determining the area for specific parts, the student employed innovative methods. For example, in one question, the student drew a rectangle around a part that couldn't be calculated using the formula (refer to Figure 7) and calculated the area of this surrounding rectangle. Subsequently, the student attempted to find the area of the remaining piece by subtracting the area of the small triangles on the side of the figure from the overall area. While the student initially faced difficulties in unfamiliar methods, particularly in the initial stages, it is noteworthy that the student gradually overcame these challenges and successfully calculated the areas of those pieces with the techniques they developed. The answer and dialogue of the student coded M-S2 are presented below:

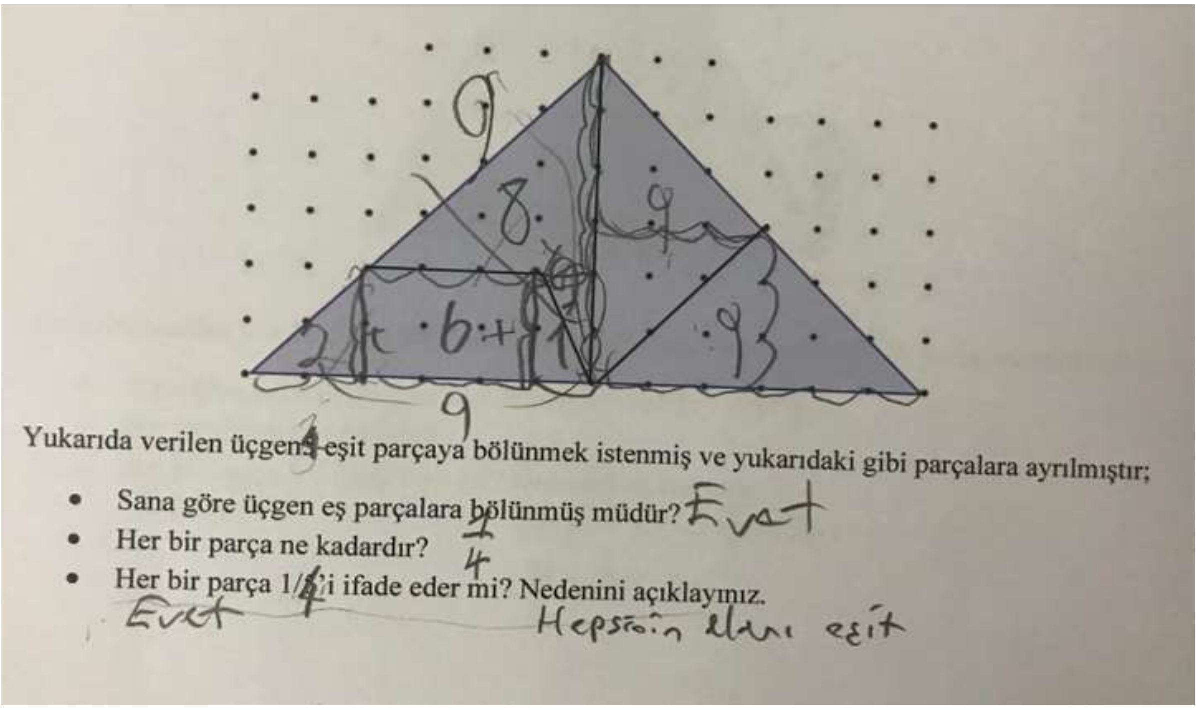

Figure 7 The Answer of Student Coded M-S2

M-S2: I will do the same thing again.

M-S2:1,2,3,4,5,6. that is also 3. 18 divided by 2 is 9. This is the 9th.

M-S2: This is 6, this is 2, and 1 is 9 in total.

M-S2: If we divide it like this, this will also be 8 and 9 from 1.

M-S2: Yes, all the pieces were equal. It means ¼.

Researcher: What if the areas were not equal?

M-S2: Then we couldn't say ¼.

The student coded M-S2 consistently displayed a tendency to decompose the shape and utilize formulas for area calculations. When faced with challenges in calculating specific areas, the student employed a strategy of transforming the part into a rectangle by drawing lines. This approach involved determining the area of the entire shape, subsequently calculating the shaded area by subtracting the areas of the smaller parts. Additionally, the student accurately determined that each piece comprised 9 unit squares, expressing the corresponding fraction as 1/4. This capability demonstrates the student's proficiency in creating equal parts and articulating the relationship between the part and the whole.

Conclusion, Discussion and Recommendations

The study aimed to assess students' proficiency in utilizing geometric area measurement knowledge and fraction understanding, particularly in determining fractions related to area models. Student responses to fraction area model questions were analyzed based on the identified profiles: Profile 1 (pre-internalization), Profile 2 (internalization), Profile 3 (condensation), and Profile 4 (reconstruction).

Upon examining the findings related to the area model, it was observed that students were predominantly distributed across the pre-internalization (Profile 1) and reconstruction (Profile 4) stages. Additionally, students were found in each profile category, showcasing a diverse range of responses. Notably, 6th, 7th, and 8th-grade students participated in both Profile 1 and Profile 4. Specifically, students coded as L-S3 and M-S2 were at the Profile 1 level in the 8th grade, M-S5 and L-S6 in the 7th grade, and M-S8 and L-S9 in the 6th grade. On the other hand, students with codes G-S1 and M-S2 at the Profile 4 level were in the 8th grade, G-S4 in the 7th grade, and G-S7 and M-S8 in the 6th grade. Furthermore, specific students were categorized into different levels: L-S3, M-S2, M-S5, L-S6, M-S8, and L-S9 were at the pre-internalization (Profile 1) level. Meanwhile, M-S8 demonstrated proficiency at the internalization (Profile 2) level, G-S7 exhibited answers aligning with the condensation (Profile 3) level, and students coded G-S1, M-S2, G-S4, G-S7, M-S8 provided responses at the reconstruction (Profile 4) level.

From the study's findings, it was inferred that students' distribution across profiles was related to their success levels. Upon examining students at Profile 1 level (L-S3, M-S2, M-S5, L-S6, M-S8, L-S9), it was noted that students at Profile 4 level (G-S1, M-S2, G-S4, G-S7, M-S8) generally demonstrated moderate to good achievement levels. The profiles revealed that students with moderate and good success could effectively articulate the concept of fractions and establish connections with area measurement. Conversely, students with low achievement levels struggled to express the concept of fractions and link it to area measurement. Interestingly, students at the good achievement level, coded as G-S1 (8th grade), G-S4 (7th grade), and G-S7 (6th grade), predominantly provided answers at Profile 4 and Profile 3 levels. Those at the intermediate level, such as M-S2 (8th grade), M-S5 (7th grade), and M-S8 (6th grade), exhibited diverse responses across all levels. Students at the low achievement level, including L-S3 (8th grade), L-S6 (7th grade), and L-S9 (6th grade), generally answered at the Profile 1 level, occasionally reaching higher levels in familiar questions but predominantly remaining at Profile 1. The study revealed that there was no straightforward relationship between profiles and age or grade levels. For instance, a 6th-grade student was found in both Profile 1 and Profile 4, while an 8th-grade student exhibited responses in profiles 1 and 4. Consequently, grade levels did not dictate the determined levels of geometric area measurement knowledge and fraction knowledge. The findings suggested that as students progressed through higher grade levels, there was no consistent increase in their understanding of fraction content knowledge. Notably, 6th-grade students could provide answers at Profile 4 level, while 8th-grade students might respond in line with Profile 1. This conclusion aligns with Ciosek and Samborska's (2016) study, which found misconceptions about fractions prevalent across various educational levels. Similarly, in Lee and Lee's (2020) research involving pre-service teachers, many demonstrated reasoning at Profile 1 level when solving fraction-related problems. While these studies support the current findings, it's important to note that Ozansak Topçu (2019) argued that mental schemas related to fractions develop rapidly with increasing grade levels.

The study's conclusion highlights the variability in students' performance based on the specific question and geometric shape presented. For instance, the student coded M-S8 exhibited different profiles across the four area model questions, being at Profile 4 level in one question, Profile 2 level in another, and Profile 1 level in two questions. This variability is evident when examining the questions individually; the student demonstrated Profile 1 level in the area model question featuring a triangle, Profile 2 level in the rectangular area model question, and Profile 4 level in the square-shaped area model question. This observation aligns with previous studies by Tan (1998) and Gürefe (2018), which suggested that students often resort to using formulas when calculating the areas of basic shapes like triangles and rectangles. Additionally, Tabak, Ahi, Bozdemir, and Sarı (2010) found that while students were successful in expressing fractions in the area model, their interpretation faced challenges when applied to geometric shapes they were less familiar with, such as triangles and trapezoids. These findings underscore the influence of both question structure and geometric shape on students' ability to integrate fraction knowledge with geometric area measurement.

The study revealed variations in area calculation methods based on students' success levels. Students with low success levels were observed to have errors related to area calculation, such as point counting and interval counting. Conversely, students with a good level of success tended to employ calculations with formulas, applying the rules provided in the questions. Interestingly, students at the intermediate level sought alternative methods, possibly due to difficulty recalling specific rules. An illustrative example is the case of the student coded M-S8, who, when faced with uncertainty in calculating the area of a triangle, opted to combine triangles to form a rectangle. Similarly, in the frame question, this student calculated the area painted in yellow to express the part-whole relationship. Subsequently, the student subtracted this area twice from the overall area and concluded that it represented 1/3. This diverse range of approaches showcases how students adapt their strategies based on their understanding and recall of geometric and fractional concepts.

The study noted that students who responded at Profile 2 and Profile 3 levels predominantly employed the unit square counting strategy for area measurement. During this process, students counted complete unit squares as one and sometimes completed incomplete ones to reach a unit count. However, errors occurred, such as combining inappropriate parts and counting them as a whole. Rectangular and square-shaped pieces facilitated accurate unit counting, while errors were more common when dealing with triangles, where counting and joining pieces proved challenging. Previous research by Gürefe (2018) and Torbens et al. (2004) supports the idea that students may easily make mistakes using the counting strategy. In contrast, Battista (2003) emphasized the significance of students' conceptual understanding of the area measurement formula rather than relying solely on the counting strategy. The current study observed that students frequently utilized incorrect expressions when calculating area measurement using formulas. Furthermore, students tended to perform operations based on memorized information rather than expressing the conceptual understanding of the area formula. This highlights a potential gap in the students' grasp of the underlying concepts, emphasizing the importance of promoting conceptual understanding alongside procedural knowledge.

The study observed that students faced challenges in establishing the part-whole relationship in fractions, struggling to understand how the whole is divided into equal parts. Some students incorrectly expressed fractions as 2/5 when two out of five parts were deemed equal, and 3/5 when three parts were perceived as equal. Despite assertions by various researchers (Acar, 2010; Akbaba-Dağ, 2014; Baştürk, 2016; Şen, 2021) that teachers and pre-service teachers often focus on the part-whole meaning of fractions, the current findings suggest that students may encounter difficulties in grasping this concept. In a study conducted by Yavuz Mumcu (2018) with pre-service teachers, it was noted that they struggled to establish the relationship between the part and the whole. Karaağaç and Köse (2015) reported that students tended to think fractions with the same symbols represented the same amount, overlooking the reference whole. Similarly, Olkun and Toluk-Uçar (2014) highlighted the challenges associated with the part-whole relationship in fractions due to its incorporation of spatial relations and content knowledge. As emphasized by Cramer and Whitney (2010), understanding the part-whole meaning is crucial for constructing the meaning of fractions, suggesting that greater importance should be placed on reinforcing this concept. The study also concluded that students faced difficulties in calculating area and determining fractions in questions related to compound fractions. In these questions, students often described an exact part as a whole, struggling to identify the fraction part accurately. This finding aligns with research by Kurt (2006), who identified common mistakes in questions related to the area model of compound fractions among 6th, 7th, and 8th-grade students. Topçu (2020) similarly noted deficiencies in compound fractions among students in his study. Uslu (2006) found that a significant percentage of 5th, 8th, and 10th-grade students had problems expressing compound fractions verbally and representing them with a model. Ma (1999) suggested that these challenges might stem from a neglect of the conceptual structure during fraction teaching.

The findings not only revealed the correctness of the students' problem-solving approaches but also demonstrated their competence in integrating and explaining fundamental mathematical concepts. For instance, students coded M-S8 and G-S7 articulated that the fraction was 1/3 by subtracting the painted area from the whole area twice in order to express the fraction in the frame question. Similarly, students coded M-S2 and G-S4 attempted to establish the relationship between the area and the fraction by employing various strategies, such as finding and subtracting the area of the whole or calculating the area by dividing the shape into parts, to determine the areas of the small parts in the given area model questions. These examples underscore the significance of not only the accuracy of the approach but also the integration of basic mathematical concepts in solving such problems.

The results of this study suggest that students in Grades 6 to 8 exhibit varying levels of understanding in commonly used models and mathematical language. The research provides insights into ways to elevate students to higher levels of understanding and highlights common mistakes made by students in both geometric measurement and fractions. Observations in the study indicate that students struggle with clarifying units, distinguishing between the knowledge of measuring perimeter and area, and correctly determining fractions during counting and other estimations. The findings also illustrate the diverse strategies and methods employed by middle school students in different segmented area models, reflecting distinct mental schemas. Encouraging students to discover connections between concepts, surpass the limits of their previous knowledge, and enhance their understanding of intuitive thinking, strategy creation, and the representation of units, quantities, and fractions emerges as a valuable and meaningful exercise.

The findings not only affirmed the correctness of students' problem-solving approaches but also gauged their success in explaining and integrating fundamental mathematical concepts. As a result, mathematics teachers are encouraged to design tasks that integrate various areas in mathematics, fostering connections between different mathematical concepts within their classroom practices.

The study revealed that students encountered less difficulty with rectangular fractional area models compared to triangular area models. To enhance fraction teaching, it is suggested that educators incorporate various types of area models, including different segmented area models, both in classroom applications and textbooks.

Moreover, the research indicated that students faced challenges in calculating area and determining fractions in questions related to compound fractions. In these instances, students often misinterpreted an exact part as a whole being painted, struggling to identify the fractional part. It is recommended to conduct similar studies for pre-service teachers to raise awareness and expand their content knowledge.

This study focused on sixth, seventh, and eighth-grade students. However, it can be expanded to include teachers and teacher candidates. Area model questions, which are usually presented without segmentation, can also be addressed using conventionally provided area model questions. This research is qualitative in nature, and the participants were restricted to nine students within a single school. Consequently, conducting additional studies with a larger sample size is possible. Furthermore, beyond qualitative research, quantitative research can be explored.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

There was no conflict of interest in this study.

Funding

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CRediT author statement

This study is part of the master's thesis of the first author under the supervision of the second author.

Research involving Human Participants and/or Animals

This research was conducted with the permission obtained with the decision of the Social and Human Scientific Research and Publication Ethics Committee of Uşak University, dated 09/09/21 and numbered 2021-168.

Ortaokul Öğrencilerinin Kesir ve Geometrik Alan Ölçme Bilgisini Birbirine Bağlama Becerisinin Belirlenmesi

Özet:

Bu çalışmada ortaokul öğrencilerinin kesir bilgisi ve geometrik alan ölçme Bilgisi ortaya çıkarılarak kesri belirlerken alan ölçme bilgisini nasıl kullandığı belirlenmiştir. Durum çalışması şeklinde tasarlanan bu çalışma 6, 7 ve 8. sınıflardan belirlenen dokuz öğrenci ile yürütülmüştür. Birebir görüşmeler yoluyla toplanan veriler betimsel analiz kullanılarak analiz edilmiştir. Bulgular sonucunda katılımcıların kesir ve alan ölçme bilgisinin ön içselleştirme, içselleştirme, yoğunlaştırma ve yenidenleştirme profillerinden çoğunlukla ön içselleştirme profilinde olduğu belirlenmiştir. Öğrencilerin farklı bölümlendirilmiş kesir alan modellerinde, değişik stratejiler ve yöntemler kullandıklarını, farklı zihinsel şemalar ortaya çıkardıklarını ve öğrencilerin görevlere verdiği yanıtların kesir bilgisi ve alan ölçme bilgisini ortaya çıkardığı görülmüştür. Araştırmanın sonucunda kesir kavramı gibi önemli bir kavramı öğreten matematik öğretmenlerinin ve sınıf öğretmenlerinin temel matematiksel kavramları bütünleştirebilen görevler tasarlamaları ve farklı alanlar arasında bağ kurmaları konusunda öneride bulunulabilir.

Anahtar kelimeler: Kesir, alan ölçme, ortaokul öğrencileri

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Research Article

Review of Mathematical Modeling Research: A Descriptive Content Analysis Study

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Abstract – Recently, mathematical models and modeling practices have become popular in associating mathematics with real-life problems and, hence understanding this relationship. Accordingly, the mathematical modeling skill has been adopted in the standards and by researchers. Understanding the use of mathematical modeling in the learning and teaching processes of mathematics education will contribute to the future of the field. This study aimed to review the trends in mathematical modeling literature using leading research studies. This study reviewed the various types of studies indexed in the Web of Science database between 2000 and 2021 regarding how they addressed modeling. As well as mathematical modeling approaches used, the studies were reviewed in terms of basic characteristics such as publication year, sample, and research method. We evaluated studies using a form developed by the researchers, and the study revealed an increase in the number of studies over the years, and the studies were conducted mostly with pre-service teachers. In addition, we observed that research studies employed mostly small samples to closely monitor the modeling process.

Keywords: mathematical modeling, mathematics, modeling, mathematics education, descriptive content analysis

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Introduction

Mathematical modeling education has attracted ever-increasing interest in the last twenty years. One of the most significant purposes of mathematics education is to cultivate individuals with the ability to apply mathematics in everyday life (Kaiser, 2005) and hence develop students' abilities to solve problems in everyday life (English & Watters, 2005). Besides, mathematical modeling problems develop students' mathematical thinking and problem-solving skills to a greater extent than traditional problems (English & Watters, 2005). The basic components of mathematical modeling are employed within the framework of international research such as PISA, which aims at applying the mathematics taught in schools to everyday life and which centers around mathematics literacy (Organisation for Economic Co-operation and Development [OECD], 2013), has progressively popularized the mathematical modeling approach. The popularization of mathematical modeling in mathematics education has led many countries to include this approach in their curricula from elementary education to higher education (Australia Ministry of Education, 2008; Common Core State Standards for Mathematics, 2011; Ministry of Singapore Education, 2007; National Council of Teachers of Mathematics [NCTM], 2000).

Various pursuits in mathematics education have sought to change the curriculum structure in schools in the mathematical modeling area while inspiring different researchers interested in mathematical modeling. Lack of desired development in students' problem-solving skills (Lesh & Zawojewski, 2007) and recognizing the significance of modeling in problem-solving in terms of coping with real-world situations and a competency-based economy have led to a shift from problem-solving to mathematical modeling in mathematics education (Chan, 2013). Mathematics researchers have turned towards modeling studies because it supports teaching particular concepts in mathematics and developing positive attitudes towards mathematics (Blum & Ferri, 2009). As a result, the number of research studies on mathematical modeling has tended to increase lately, and studies addressing mathematical modeling with respect to different aspects have started to be published in mathematics education (Blum & Ferri, 2009). With advancements in learning approaches and technology, we can come across modeling studies aiming at higher-order cognitive skills supported with technology (Çekmez, 2020; Lingefjärd, 2013; Siller & Greefrath, 2010). Mathematical modeling is also an integral part of the mathematics curriculum in many countries, both at primary and secondary school level, and at the higher education level, where mathematics often functions as a service subject for other disciplines (Durand-Guerrier et al, 2021). Mathematics, especially as a service course, has a critical role in understanding and solving the problems of other disciplines (Çevikbaş et al., 2022). Mathematical modeling, which is employed in various fields such as applied mathematics, Physics, Biology, and Engineering (Damlamian et al., 2013) as well as social fields of application (Ferruzzi &

Almeida, 2013; Laudares & Lachini, 2005), is also used in mathematics education with various aims and approaches (Kaiser et al., 2006; Niss et al., 2007).

Despite the prominent role of mathematical modeling in mathematics education and progressively increasing modeling studies lately, the studies on mathematical modeling are not at the desired level yet (Ferri & Blum, 2013; Stillman et al., 2015). Furthermore, the literature has not reached a consensus on the meaning and use of modeling (Aztekin & Taşpınar-Şener, 2015). However, there is widespread consensus on the critical importance of modeling competencies and the modeling cycle. Despite this, there is no extensive research literature on the specific contributions of short- and long-term mathematical modeling approaches at school and higher education levels to the development of these competencies. This represents a significant research gap in the field and is of critical importance for future scientific investigations (Çevikbaş et al., 2022). Systematizing different approaches and understandings and addressing modeling with a holistic perspective may enable a better understanding of these studies, which have been gaining increasing significance in mathematics education. Therefore, the current study aims at revealing the current state of mathematical modeling studies in mathematics education through descriptive content analysis. Accordingly, research studies in the literature are systematically analyzed in this study, employing the basic concepts related to mathematical modeling, modeling approaches, and modeling types.

Mathematical Modeling

The definitions of mathematical modeling in the literature vary according to the researchers' perspectives and what they attribute to mathematical modeling (Bukova Güzel, 2016). The elaboration of the process and featured characteristics stand out in these definitions (Çavuş Erdem, 2018). Pollak (1979), who is one of those using real-life problems in mathematics educations for the first time, defined mathematical modeling as the interaction of the world outside mathematics with mathematics. Lesh and Doerr (2003) defined mathematical modeling as transforming a real-life problem into a mathematics problem, forming the mathematical models needed to solve the problem, and interpreting the results. They thus emphasized the explanation of real-life with mathematical models. Borromeo-Ferri (2006) considers mathematical modeling a complicated and circular process that includes the transitions between the mathematical world and real life. Galbraith and Clatworthy (1990) figured mathematical modeling as applying mathematics in solving unstructured problems of real-life situations. These definitions suggest that mathematical modeling is a cyclical process in which the real-life and mathematics world are associated. Problems not including needed information for solutions are solved through mathematization with the aid of models, and the results are evaluated and adapted to real life. Individuals need specific competencies to be able to perform this modeling process successfully. Maaß (2006) lists these competencies as the knowledge, skills, ability, willingness to model, and metacognitive skills an individual needs to carry out the mathematical modeling process adequately and in line with the aims. The skill of modeling involves transferring a real-life case to the mathematical world with mathematical operations and hence associating the result with real life; however, modeling competency includes much more than this process. There are several researchers who define this process and various competencies working in the mathematical modeling field in the literature (Berry & Houston, 1995; Blum & Leiβ, 2007; Borromeo-Ferri, 2006; Kapur, 1982; Lesh & Doerr, 2003; Pollak, 1979; Schwarz et al., 2008). The most common and well-known among these is the modeling process introduced by Borromeo-Ferri (2006), and the modeling competencies used in this process are presented in Figure 1.

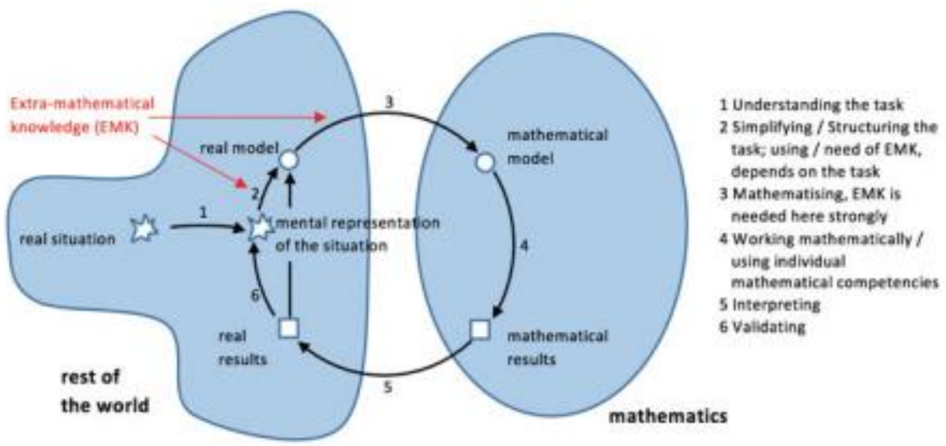

Figure 1 Mathematical Modeling Process (Borromeo-Ferri, 2006)

The mathematical modeling process is illustrated in Figure 1 in a cyclical form involving seven sub-processes. These sub-processes include understanding the task, simplifying and structuring the task (using the extra mathematical knowledge needed for the task), mathematizing, working mathematically (using individual mathematical competencies), interpreting, validating, and presenting. Accordingly, a mathematical modeling cycle starts with a real-life situation or task, and the problem is defined with a non-mathematical language. However, the problem should not be structured, and it should urge students to think. In the second step, students read, imagine, draw and form a table to make sense of the task or problem. Then, students form, examine, associate the needed data, and form hypotheses and assumptions. Thus, they comprehend the associations. At this phase, students perform operations using a mathematical concept and rule to prove the associations, assumptions, and hypotheses with the data at hand. This is the step where the model is math-oriented at the maximum level, and students solve the problem mathematically at the end of this step. The last step is the one where students control the validity of the cycle and decide on its accuracy. If the model formed is mathematically accurate and the process is appropriate, the obtained result is interpreted for real life and then reported. However, if the result is unreasonable and inaccurate, the modeling cycle starts again, and students continue the process until they find an appropriate and accurate result.

The modeling competencies (skills) mentioned above partly share similarities with problem-solving skills. Modeling problems are a particular dimension of problem-solving. According to Galbraith and Catworthy (1990), mathematical modeling is the application of mathematics to unstructured problems in real life. In other words, modeling problems have to do with non-routine real-life problems. Nevertheless, problem-solving involves both routine and non-routine problems. Verbal (routine) problems are not included in mathematical modeling problems. Extra mathematical knowledge regarding ambiguous conditions is needed to solve modeling problems (Schukajlow et al., 2018). Similarly, a number of researchers arguing that routine problems are not adequate to enhance students' problem-solving skills (Blum & Niss, 1991; English & Watters, 2004; Henn, 2007; Lesh & Doerr, 2003) have focused on developing open-ended, non-routine real-life mathematical modeling activities in which there are not fixed instructions to direct students. Research has revealed that mathematical modeling contributes students to gain learning outcomes such as transferring mathematical concepts in real life (Lesh & Doerr, 2003; Lesh & Harel, 2003), having positive attitudes towards mathematics (Blum, 2011; Borromeo Ferri, 2009), and developing metacognitive knowledge and skills (Blum & Ferri, 2009; MaaɃ, 2006) and mathematical reasoning skills (Chamberlin & Moon, 2008; Zawojewski et al., 2003;).

Mathematical Modeling Approaches

Studies on mathematical modeling include different perspectives and theories (Aztekin & Taşpınar-Şener, 2015; Erbaş et al. 2014; Kaiser et al., 2006; Niss et al., 2007). Though these perspectives are not clearly different from each other, it is possible to define the aspects they address. This part includes the opinions of researchers' who discussed various aspects of mathematical modeling.

Kaiser and Sriraman (2006) classified mathematical modeling approaches in six categories, in the most general sense. “Realistic and applied modeling” in this categorization grounds on developing modeling competencies through applications. It aims to develop students’ problem-solving and modeling skills. Contextual modeling aims at psychological goals related to the subject. Students are provided with real-life tasks. It is thus assumed that students can attain meaningful learning by experiencing mathematical concepts in appropriate contexts. Educational modeling is one of the most frequently used modeling types. It focuses on structuring learning processes and developing content. Educational modeling can be considered as an intersection of realistic modeling perspective and contextual modeling perspective. This perspective aims to arrange learning environments and processes that are appropriate for mathematical modeling to teach concepts. Socio-critical modeling aims to develop a critical perspective towards the social environment, and it focuses on social and cultural aspects of mathematics. With a socio-critical modeling perspective, mathematics education emphasizes students' gaining critical thinking skills in line with society and social environments. Discussions from simple to complex ones contribute to students' critical thinking. Another perspective is epistemological modeling which is based on a theoretical and philosophical perspective. It gives particular importance to mathematical concepts, the associations between them, and students' interpretations regarding these concepts. According to this perspective, realistic context is of secondary importance in mathematical modeling activities, and each structure that includes mathematics is accepted as a mathematical modeling activity. The last perspective, cognitive modeling, is based on cognitive processes. This perspective is related to analyzing cognitive and metacognitive thinking processes in mathematical modeling (Bukova Güzel, 2016).

The second categorization for mathematical modeling is mathematical modeling as a goal and as a tool. Mathematical modeling as a goal perspective aims at equipping students with modeling skills to solve problems related to real-life situations, and then using and developing these skills while mathematical modeling as a tool perspective targets teaching mathematical concepts in the curricula and using modeling as a tool for this (Galbraith, 2012; Lesh & Doerr, 2003). In addition, mathematical modeling as a goal perspective focuses on modeling competencies and skills, aiming to teach mathematical modeling. On the other hand, in mathematical modeling as a tool, establishing context to teach mathematics in a meaningful way is emphasized. The aim here is to use mathematical modeling to teach mathematics (Aztekin & Taşpınar-Şener, 2015; Kertil et al., 2016). Additionally, mathematical modeling as a goal perspective stresses the process representing forming, developing, and generalizing mathematical structures (Erbaş et al., 2014). In brief, in mathematical modeling as a goal perspective, the focus is modeling competencies, and thus use, and development of modeling skills in daily life problems is emphasized. Therefore, there is a flow from real life to mathematics. In mathematical modeling as a tool perspective, the focus is on teaching a mathematical concept. So, this should be taught in a real-life context, and hence there is a flow from mathematics to real life.

As well as the approaches mentioned above shaping mathematical modeling studies, Berry and Houston (1995) categorized mathematical modeling into four groups: experimental modeling, theoretical modeling, dimensional analysis, and simulation modeling. There are also other modeling approaches that enrich mathematical modeling, such as Realistic Mathematics Education, highlighted by Freudenthal (1991), and Model and Modeling Perspective (MMP), put forth by Lesh and Doerr (2003).

The differentiation observed in modeling studies may be accounted for by the fact that mathematical modeling in classroom environments and instructional processes is not at the desired level across the world (Blum & Borromeo-Ferri, 2009). In the same vein, Aztekin and Taşpınar-Şener (2015) examined the literature and revealed that the studies did not have adequate content and variety, and the studies were mainly carried out with pre-service teachers.

Understanding the modeling processes and cycle can be vital in developing modeling competencies. Therefore, there is a need for systematic review studies that address more variables in this field. It is also known that more research is needed to evaluate measurement tools and approaches to promote mathematical modeling in schools and universities (Schukajlow et al., 2018). Although the studies in modeling literature are limited, carrying out a systematic review of these studies is of critical significance. When looking at the literature, the comprehensive literature review conducted by Kaiser and Brand (2015) can be considered the starting point of systematic review studies on mathematical modeling. However, this review consists of examining modeling studies in the proceedings of conferences such as International Conference on the Teaching of Mathematical Modeling and Applications (ICTMA) and International Congress on Mathematical Education (ICME), rather than reputable databases such as Web of Science (WOS). Çevikbaş et al. (2022) is an important study that compiles research in reputable databases in the field. In this research, mathematical modeling competencies were used as the main keyword and were discussed in terms of different variables. However, in this systematic review, it was determined that mathematical modeling was not discussed as a goal and tool or in terms of mathematical modeling approaches. An examination of review studies on mathematical modeling in the literature suggests that these studies review articles (Albayrak & Çiltaş, 2017; Aztekin & Taşpınar-Şener, 2015) or dissertations (Yenilmez & Yıldız, 2019) published in a particular country. So there are limited and national review studies. The current study has a broader perspective and reviews studies published in other countries and journals indexed in WOS. This study aimed at gathering current studies in the field in a mutual framework, taking into account the themes put forth by studies addressing different aspects of the subject (Aztekin & Taşpınar-Şener, 2015; Erbaş et al., 2014; Kaiser, 1995). This study, which gathers together current literature on mathematical modeling and is expected to guide future research, aimed to review the literature through descriptive content analysis. This study offers a systematic review of the studies regarding mathematical modeling, identified as a result of certain parameters among the studies published in journals indexed in WOS (Social Science Citation Index [SSCI] Journals). The themes created by the researchers are explained in detail in the method section of the study. In line with the purpose of the study, the research questions are as follows:

- How do mathematical modeling studies in the WOS database distribute in terms of characteristics such as publication year, sample level, country, and research method?
- How and with what purposes do the mathematical modeling studies were used in the studies?
- Which mathematical modeling approaches were used commonly in the studies?

Method

Article Selection Process

Researchers define a set of criteria for data collection in systematic review studies. Data quality is of great significance in these research studies (Hwang & Tsai, 2011). Criterion selection strategy is crucial for a better description of the field (Kitchenham et al., 2009). These criteria may include selecting all articles published in a field or limiting the review to indexes such as SSCI, which is thought to have high research quality, and became prominent thanks to indexing articles for a long time (Zhang & Leung, 2014). In the current study, we selected mathematical modeling articles published in journals in the SSCI database. We accessed the SSCI database through the WOS website and performed a search on this page.

By using the advanced search option on the page, the search made with the help of logical expressions [TS= ("math*" AND "education") AND TS= ("modeling" OR "modeling")] has been customized so as not to exclude the studies related to mathematical modeling. The starting point concerning publication year was 2000, and the latest date was 5 January 2021, when the search was performed for the last time. The search resulted in 941 studies. The number of studies decreased to 260 after filtering the search with being indexed in SSCI, open access, and English publication language. In selecting these studies, researchers (experienced in mathematics education) examined the articles elaborately and identified 42 studies that addressed modeling applications in mathematics education. The criteria in this examination were having modeling education content in the study and not including modeling applications in other disciplines (such as physics or biology). The studies on which the researchers could not agree were excluded. Table 1 presents inclusion and exclusion criteria.

Table 1 Article Selection Criteria

Inclusion criteria	Exclusion criteria
• Studies addressing education applications of mathematical modeling. • Articles • Publications in English	• Studies using mathematical models in different disciplines (such as physics or biology) • Editorial studies • Studies focusing on other subjects despite including mathematical modeling

The studies identified in line with inclusion and exclusion criteria are provided in Table 2. Most of the articles were published in high-quality and top-end journals.

Table 2 List of Articles and Journals accessed in WOS Database

Nr	Article	Journal	Publisher	Number of articles	Impact Value	Category
1	Bal & Doğanay (2014); Çiltaş & Işık (2013); Doruk (2012); Eraslan & Kant (2015); Eraslan (2012);); Erbaş et al. (2014); Hidayat et al. (2018);	*Educational Sciences: Theory & Practice*	Codon Publications	7	0.7	Education and education research
2	Jacobs & Durandt (2017); Niss (2017); Shahbari & Peled (2015); Şen Zeytun et al. (2017); Urhan & Dost (2017)	*International Journal of Science and Mathematics Education*	Springer	5	1.578	Mathematics and science education
3	Karalı & Durmuş (2015); Krutikhinaet al. (2018); Tezer & Cumhur (2017); Zapata-Grajales et al. (2018)	*Eurasia Journal of Mathematics, Science and Technology Education*	Modestum	4	0.47	Mathematics, STEM, science and engineering education
4	Paolucci & Wessels (2017)	*Journal of Teacher Education*	Sage	1	3.600	Teacher education and standards
5	Aztekin & Taşpınar-Şener (2015); Şahin & Eraslan (2016)	*Eğitim and Science*	TED	2	0.740	Education and education research

6	Frejd & Bergsten (2016); Hankeln (2020); Shahbari & Tabach, 2020; Wake (2014)	*Educational Studies in Mathematics*	Springer	4	1.500	Mathematics education
7	Dewolf et al. (2015)	*Instructional Science*	Springer	1	1.734	Education and education research
8	Mentzer et al. (2014)	*International Journal of Technology and Design Education*	Springer	1	1.326	Technology and design education
9	Gainsburg (2013)	*Mathematical Thinking and Learning*	Taylor & Francis	1	1.393	Education and education research
10	Kjeldsen & Blomhøj (2013)	*Science & Education*	Springer	1	1.266	Mathematics and science education, education history and research
11	Hickendorff (2013)	*Cognition and Instruction*	Taylor & Francis	1	2.516	Education and education research
12	Doruk & Umay (2011)	*Hacettepe University Journal of Faculty of Education*	Hacettepe University	1	0.18	Education and education research
13	Kim & Kim (2010)	*Asia Pacific Education Review*	Springer	1	0.761	Education and education research
14	Barquero et al. (2018); Chang et al. (2020); Dawn (2018); Frejd & Bergsten (2018); Galleguillos & de Carvalho Borba (2018); Hernandez-Martinez & Vos (2018); Orey & Rosa (2018); Schukajlow et al. (2018); Sevinc & Lesh (2018); Villarreal et al. (2018)	*ZDM – Mathematics Education*	Springer	10	1.256	Mathematics education
15	Cekmez (2020)	*Interactive Learning Environments*	Taylor & Francis	1	1.929	Education and education research
16	Asempapa & Brooks (2020)	*Journal Of Mathematics Teacher Education*	Springer	1	1574	Education and education research

Coding and Data Analysis

The researchers coded all the articles and then analyzed them. To ensure coding reliability, first, randomly selected 15 articles were coded by the researchers independently. The results were close to each other in this coding, and then the researchers continued coding the articles independently. In the next step, the codes were compared, and the researchers evaluated the codes with disagreements together and reached a compromise. After identifying the number of "consensus" and "disagreement" among the codes, reliability was calculated using the reliability formula recommended by Miles and Huberman (1994):

Reliability = Consensus / (Consensus + Disagreement)

Reliability values over 70% indicate reliability (Miles & Huberman, 1994). Reliability was calculated as 92.4% in the current study. The researchers used office programs for coding, and the analysis was recorded using a standard form. The coding procedure was performed in line with research questions. The publication year of the article was determined based on the publication date. The participants were categorized as teachers, pre-service teachers, and students, and the category of students was divided into sub-categories. The samples were also categorized in terms of size. The research designs were grouped as qualitative, quantitative, and mixed designs. In addition, how the modeling was addressed in the studies was also categorized. These categories and their details are provided in the findings section.

Findings and Discussions

Forty-two studies on modeling selected within the scope of the current study were examined in line with the analysis categories. Noteworthy findings in each table are explained below the related tables.

Table 3 Distribution of studies on modeling in terms of sample

Sample	Frequency (f)	Percentage (%)	Articles
Elementary school students	2	4,8	Eraslan & Kant (2015); Şahin & Eraslan (2016)
Lower secondary school students	5	11,9	Doruk (2012); Doruk & Umay (2011); Hickendorff (2013); Shahbari & Peled (2014); Tezer & Cumhur, (2017)
High school students	4	9.5	Chang et al. (2020); Hankeln (2020); Mentzer et al.(2014); Zapata-Grajales et al. (2017)
University students	5	11.9	Dewolf et al. (2013); Gainsburg (2013); Hernandez-Martinez & Vos (2018); Kjeldsen & Blomhøj (2013); Niss (2017)
Pre-service teachers	9	21.4	Bal & Doğanay (2014); Cekmez (2020); English (2017); Çiltaş & Işık (2013); Eraslan (2012); Hidayat er al. (2018); Karalı & Durmuş (2015); Şen Zeytun et al. (2017); Villarreal et al. (2018)
Teachers	5	11.9	Asempapa & Brooks (2020); Barquero et al. (2018); Dawn (2018); Galleguillos & de Carvalho Borba (2018); Sevinc & Lesh (2018)
Others	12	28.6	Aztekin & Taşpınar-Şener (2015); Erbaş et al. (2014); Frejd & Bergsten (2016, 2018); Jacobs & Durandt (2017); Kim & Kim (2010); Krutikhina et al. (2018); Orey & Rosa (2018); Schukajlow et al. (2018); Shahbari & Tabach (2020); Urhan & Dost (2017); Wake (2014);
Total	42	100,0	

It is observed that studies carried out with pre-service teachers are more frequent among studies on modeling in the literature. In addition, "other" studies of literature review, book review, and studies with mixed participants have a similar percentage in the literature. There are few studies carried out with elementary school and high school students.

Table 4 Distribution of studies on modeling in terms of number of participants

Participants	Frequency (f)	Percentage (%)	Articles
Less than 50	24	57.1	Aztekin & Taşpınar-Şener (2015); Bal & Doğanay (2014); Barquero et al. (2018); Cekmez (2020); Çiltaş & Işık (2013); Dewolf et al. (2015); Eraslan (2012); Eraslan & Kant (2015); Frejd & Bergsten (2016, 2018); Gainsburg (2013); Galleguillos & de Carvalho Borba (2018); Hankeln (2020); Hernandez-Martinez & Vos (2018); Karalı & Durmuş (2015); Kjeldsen & Blomhøj (2013); Mentzer et al. (2014); Niss (2017); Sevinc & Lesh (2018); Shahbari & Tabach (2020); Şahin & Eraslan (2016); Şen Zeytun et al. (2017); Villarreal et al. (2018); Zapata-Grajales et al. (2018)
51-99	6	14.3	Dawn (2018); Doruk (2012); Jacobs & Durandt (2017); Kim & Kim (2010); Paolucci & Wessels (2017); Shahbari & Peled (2014)
100+	8	19	Asempapa & Brooks (2020); Chang et al. (2020); Doruk & Umay (2011); Hickendorff (2013); Hidayat et al. (2018); Orey & Rosa (2018); Schukajlow et al. (2018); Tezer & Cumhur (2017)
Other	4	9.5	Erbaş et al. (2014); Krutikhina et al. (2018); Urhan & Dost (2017); Wake (2014)
Total	42	100,0	

More than half of the articles (57.1%) worked with participants that were less than 50. This sample size was followed by participant groups of 100 and over (19%) and between 51 and 99 (14.3%) participants. The ‘other’ category includes studies in which the numbers of participants were not stated, and this group has the least frequency (9.5%).

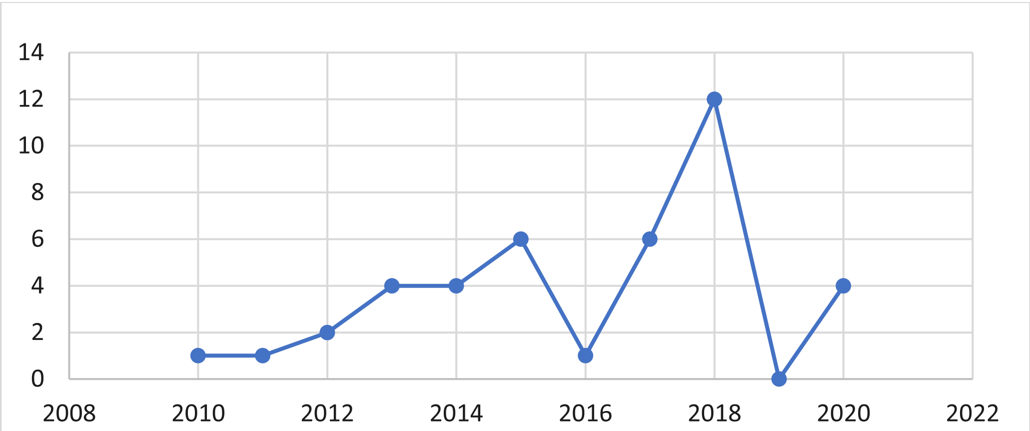

Figure 2 Number of Publications

The number of research studies on mathematical modeling gained pace after 2013. In other words, there was a limited number of studies before 2013, and the number of studies increased rapidly in 2015 and afterwards.

Table 5 Distribution of studies on modeling in terms of research designs

Design	Frequency (f)	Percentage (%)	Articles
Mixed	3	7,1	Frejd & Bergsten (2016); Kim & Kim (2010); Paolucci & Wessels (2017)

Quantitative	9	21,4	Asempapa & Brooks (2020); Chang et al. (2020); Dewolf et al. (2015); Doruk & Umay (2011); Hickendorff (2013); Hidayat et al. (2018); Jacobs & Durandt (2017) Tezer & Cumhur (2017); Wake (2014);
Qualitative	30	71,4	Aztekin & Taşpınar-Şener (2015); Bal & Doğanay (2014); Barquero et al. (2018); Cekmez (2020); Çiltaş & Işık (2013); Dawn (2018); Doruk (2012); Eraslan (2012); Eraslan & Kant (2015); Erbaş et al. (2014); Frejd & Bergsten (2018); Gainsburg (2013); Galleguillos & de Carvalho Borba (2018); Hankeln (2020); Hernandez-Martinez & Vos (2018); Karalı & Durmuş (2015); Kjeldsen & Blomhøj (2013); Krutikhina et al. (2018); Niss (2017); Orey & Rosa (2018); Schukajlow et al. (2018); Shahbari & Peled (2015); Shahbari & Tabach (2020); Sevinc & Lesh (2018); Şahin & Eraslan (2016); Şen Zeytun et al. (2017); Urhan & Dost (2017); Villarreal et al. (2018); Wake (2014); Zapata-Grajales et al. (2018)
Total	42	100,0	

Qualitative research designs predominated the studies on modeling in the literature. In most of these studies, modeling activities were used, and participants' modeling processes were analyzed. On the other hand, quantitative studies constituted 20% of the studies. Studies employing mixed designs were the least. This distribution shows us that the dominant paradigm in mathematical modeling research is the qualitative paradigm.

Table 6 Distribution of studies on modeling in terms of countries

Country	Frequency (f)	Percentage (%)	Articles
The U.S.A.	2	6,9	Fang & Guo (2016); Mentzer et al. (2014)
The U.K.	1	3,4	Wake (2014)
Belgium	1	3,4	Dewolf et al. (2015)
Denmark	2	6,9	Kjeldsen & Blomhøj (2013); Niss (2017)
Indonesia	1	3,4	Hidayat et al. (2018)
South Africa	2	6,9	Jacobs & Durandt (2017); Paolucci & Wessels (2017)
Holland	1	3,4	Hickendorff (2013);
Israel	1	3,4	Shahbari & Peled (2015)
Sweden	1	3,4	Frejd & Bergsten (2016)
California	1	3,4	Gainsburg (2013)
Cyprus	1	3,4	Tezer & Cumhur (2017)
Columbia	1	3,4	Zapata-Grajales et al. (2018)
Korea	1	3,4	Kim & Kim (2010)
Russia	1	3,4	Krutikhina et al. (2018)
Turkey	12	41,4	Aztekin & Taşpınar-Şener (2015); Bal & Doğanay (2014); Çiltaş & Işık (2013); Doruk (2012); Doruk & Umay (2011); Eraslan (2012); Eraslan & Kant (2015); Erbaş et al. (2014); Karalı & Durmuş (2015); Şahin & Eraslan (2016); Şen Zeytun et al. (2017); Urhan & Dost (2017)
Total	42	100,0	

The distribution of the articles in terms of countries demonstrates that the studies conducted in Turkey constituted 41% of all studies in the sample. The studies conducted in the U.S.A., Denmark, and South Africa corresponded to 21% of all studies. Other countries had just one study on mathematical modeling.

Table 7 Distribution of studies on modeling in terms of how modeling is addressed

Examination of Modeling	Frequency (f)	Percentage (%)	Articles
Modeling as a goal	13	31.0	Dawn (2018); Doruk & Umay (2011); Erbaş et al. (2014); Frejd & Bergsten (2016, 2018); Krutikhina et al. (2018); Orey & Rosa (2018); Schukajlow et al. (2018); Sevinc & Lesh (2018); Şahin & Eraslan (2016); Urhan & Dost (2017); Wake (2014); Zapata-Grajales et al. (2018)
Modeling as a tool	29	69.0	Asempapa & Brooks (2020); Aztekin & Taşpınar-Şener (2015); Bal & Doğanay (2014); Barquero et al. (2018); Cekmez (2020); Chang et al. (2020); Çiltaş & Işık (2013); Dewolf et al. (2015); Doruk (2012); Eraslan (2012); Eraslan & Kant (2015); Gainsburg (2013); Galleguillos & de Carvalho Borba (2018); Hankeln (2020); Hernandez-Martinez & Vos (2018); Hickendorff (2013); Hidayat et al. (2018); Jacobs & Durandt (2017); Karalı & Durmuş (2015); Kim & Kim (2010); Kjeldsen & Blomhøj (2013); Mentzer et al. (2014); Niss (2017); Paolucci & Wessels (2017); Shahbari & Peled (2015); Shahbari & Tabach (2020); Şen Zeytun et al. (2017); Tezer & Cumhur (2017); Villarreal et al. (2018)
Total	42	100,0	

The studies were also examined in terms of whether modeling was used as a goal or tool in those studies. In 69% of the studies, modeling was examined as a tool. This demonstrates that the use of modeling is more common in learning-teaching processes. In other words, modeling is used to a greater extent with pedagogical purposes such as conceptual learning and arrangement of learning processes.

Table 8 Distribution of studies on modeling in terms of modeling approaches

Modeling Approach	Frequency (f)	Percentage (%)	Articles
Contextual Modeling	3	7,1	Hickendorff (2013); Paolucci & Wessels (2017); Sevinc & Lesh (2018)
Cognitive Modeling	5	11,9	Eraslan (2012); Eraslan & Kant (2015); Mentzer et al. (2014); Shahbari & Tabach (2020); Şahin & Eraslan (2016)
Educational Modeling	14	33,3	Asempapa & Brooks (2020); Bal & Doğanay (2014); Barquero et al. (2018); Chang et al. (2020); Çiltaş & Işık (2013); Dawn (2018); Doruk (2012); Galleguillos & de Carvalho Borba (2018); Hidayat et al. (2018); Kim & Kim (2010); Orey & Rosa (2018); Şen Zeytun et al. (2017); Tezer & Cumhur (2017); Villarreal et al. (2018)
Epistemological Modeling	9	21,4	Aztekin & Taşpınar-Şener (2015); Erbaş et al. (2014); Frejd & Bergsten (2016, 2018); Kjeldsen & Blomhøj (2013); Krutikhina et al. (2018); Schukajlow et al. (2018); Urhan & Dost (2017); Wake (2014)
Realistic Modeling	11	26,2	Cekmez (2020); Dewolf et al. (2015); Doruk & Umay (2011); Gainsburg (2013); Hankeln (2020); Hernandez-Martinez & Vos (2018); Jacobs & Durandt (2017); Karalı & Durmuş (2015); Niss (2017); Shahbari & Peled (2015); Zapata-Grajales et al. (2018)
Total	42	100,0	

The most frequent modeling approach used in the studies was educational modeling with a percentage of 33%, followed by realistic modeling with 26,2%. 21,4% of the studies used epistemological modeling, 11,9% used cognitive modeling, and 7,1% used contextual modeling.

Conclusions and Suggestions

The studies on mathematical modeling used in mathematics education were reviewed in the current study in terms of publication year, method, participant characteristics, countries, modeling approaches, and intended purpose of modeling use. The study revealed that research studies on mathematical modeling were quite limited at elementary, lower and upper secondary levels, while most of the studies were carried out with pre-service teachers. It is discussed in the literature that mathematical modeling is not adequately covered in elementary mathematics education (Jones et al., 2002), environment-friendly electronic worksheets and modeling activities should be used with student groups at different levels (Rojano, 2015), and, with the technological advancements, opportunities to access mathematical modeling needs to be the primary goal of all mathematics curricula (Amit, 1999; Er-sheng, 1999). Similarly, Çevikbaş et al., (2022) determined the studies on mathematical modeling competencies were mostly conducted with secondary school and high school students, and then with teacher candidates. Research on mathematical modeling is performed with pre-service teachers as opposed to elementary or lower secondary level students due to challenges of bureaucratic procedures (Aztekin & Taşpınar-Şener, 2015). Other reasons for the high number of studies with pre-service teachers may be that they are more accessible for particularly mathematics education faculty, and researchers do their research within the scope of modeling courses they offer to pre-service teachers. Additionally, researchers may believe that mathematical modeling activities with younger age groups and at lower secondary school would not be effective in forming mathematical models at the desired level. Researchers and teachers may find it hard to practice qualified mathematical modeling studies activities with younger age groups because it requires high-level pedagogical mathematics content knowledge (Aztekin & Taşpınar-Şener, 2015). It is vital to support and develop resources for integrating mathematical modeling into early childhood mathematics education (Paolucci & Wessels, 2017). There was only a single study with graduate-level participants, and there were no studies with academic's participants, which is another indicator that mathematical modeling research is performed with a limited sample variety (Albayrak & Çiltaş, 2017). Mathematical modeling studies at the K12 level can be extended and popularized because calculations can now be made with technological elements, and models can be visualized with dynamic software. Thus, the number of research studies in this field will increase. Research at the K12 level has an essential role in identifying the challenges and opportunities students experience in modeling activities, as well as students' mathematical thinking and attitudes towards valuing mathematics. Therefore, an increase of research studies at this level may help us understand mathematical modeling better and allow room for mathematical modeling in education environments at the desired level. Mathematical modeling research from the start of elementary school is important for students to develop their skills of using mathematics in real life (Jones et al., 2002). This argument invites us to research modeling at each schooling level. However, the majority of mathematical modeling research has been carried out with pre-service teachers. This indicates that researchers cannot make good use of schools that are actually areas of application. Due to bureaucratic procedures, researchers may prefer to work with pre-service teachers rather than lower and upper secondary level students. Therefore, schools should make it convenient for universities to research the K12 level. Besides, that mathematical modeling research studies were carried out with mostly pre-service teachers and teachers indicates that the instructional aspect of modeling is featured in the literature. Hence, the learning aspect of modeling should also be addressed with studies examining students' development of modeling skills in real classroom settings at elementary, lower, and upper secondary school levels.

With regard to the sample size of the studies on mathematical modeling, this study revealed that more than half of the studies used samples of less than 50 participants. This result is in parallel with findings on research designs used in mathematical modeling research. Nearly 70% of the studies employed a qualitative design, bringing about fewer numbers of participants. Another reason for lesser participants is the use of the convenience sampling method. Because researchers tend to carry out their research with smaller samples due to time restrictions and ethical procedures. The finding that nearly half of the mathematical modeling studies in Turkey had a sample size of 1-30 (Bayrak & Çiltaş, 2017; Çelik, 2017) lend its support to the current study. Then Çevikbaş et al. (2022) conducted a research and it was determined that the maximum number of samples in mathematical modeling studies was carried out with samples smaller than 50. In addition, this study demonstrated that sample size is directly related to modeling approaches. For instance, a study employing cognitive modeling approach needs to work with fewer participants by its very nature because it addresses challenges students experience in modeling processes (Eraslan, 2012; Shahbari &

Tabach, 2020; Şahin & Eraslan, 2016). However, experimental or correlational survey methods are used in modeling studies employing educational modeling approach, resulting in higher numbers of participants (Hidayat et al., 2018; Kim & Kim, 2010; Tezer & Cumhur, 2017). These findings manifest that sample size is directly affected by the design of the research study, and more importantly, the modeling approach adopted in the study.

The examination of the studies on modeling literature in terms of publication year showed that these studies gained pace after 2003. Similarly, Çevikbaş et al. (2022) found that mathematical modeling research started in 2003. A reason for the increase in the number of studies by year may be related to the fact that several countries (NCTM, 2000; Ministry of Education Singapore, 2007; CCSM, 2011) addressed mathematical modeling as a basic competency in their curricula. Besides, that the aims of mathematics education can be achieved through mathematical modeling has contributed to the increase in research studies in this field (Gürbüz & Doğan, 2019). Another reason urging mathematics educators to research mathematical modeling is anxiety stemming from the inefficiency of traditional methods and problem-solving activities in ensuring the use of students' mathematical knowledge and thinking skills in real life (Mousoulides et al, 2008). The inadequacy of routine problems in developing problem-solving skills (Blum & Niss, 1991; English & Watters, 2004; Henn, 2007; Lesh & Doerr, 2003) may have led researchers to focus on developing open-ended, non-routine, and real-life related mathematical modeling activities (Çekmez, 2020; Hickendorff, 2013). Besides, the results of international comparative examinations such as TIMSS, PISA, and PIRLS, aiming to measure the extent to which students use the knowledge they learned at school in their daily lives, are discussed by people today, and countries have started revising their education system in line with these exams, which has increased the interest in mathematical modeling research the focus of which is real-life problems. There is not an equal distribution in the number of studies in terms of year. There are no studies in some years, while there are a number of studies in some years. However, with the influence of ICTMA conferences, a steady progress has been detected in the number of mathematical modeling studies over time (Çevikbaş et al., 2022). The continuity of research is critical for the quality of mathematical modeling and reaching different samples. Therefore, more elaborate and subsequent research studies are needed.

We also examined the studies on modeling in terms of research design types and revealed that qualitative studies predominated. In some studies within the sample (Eraslan & Kant, 2015; Şahin & Eraslan, 2016; Şen Zeytun et al., 2017), modeling activities were used to figure out participants' modeling processes. Researchers may have preferred qualitative research design because they offer researchers opportunities to thoroughly examine and interpret modeling processes and modeling skills in a contextual problem. That nearly half of the research studies in mathematics education employ qualitative design (Hart et al., 2009) also supports this finding. Additionally, other reasons may be that researchers do not want to go beyond classical methods in mathematical modeling studies, and they prefer qualitative research due to their deficiencies in self-efficacy towards using new methods in application although they may have adequate theoretical and practical knowledge to use those methods (Çelik, 2017). There are few studies addressing modeling with a quantitative perspective. There are quantitative studies that revealed that metacognition affected mathematical modeling positively (Hidayat et al., 2018), students were more successful with the education practiced with mathematical modeling method than 5E model with regard to achievement in mathematics and problem-solving skills (Tezer & Cumhur, 2017), and a scale development study aiming to identify mathematics teachers' attitudes towards mathematical modeling applications (Asempapa & Brooks, 2020). However, these studies have a low percentage among the studies in the literature. On the other hand, Çevikbaş et al. (2022) also found that mostly quantitative studies were carried out, followed by qualitative studies. The emergence of such a result can be interpreted as the fact that the studies examined in the studies are based on different years or the search terms used in the research are different. Therefore, researchers can conduct comparative, causal correlational studies and studies that employ regression and structural equation modeling. Besides, mixed-method studies also have a low percentage among the studies (Frejd & Bergsten, 2016; Kim & Kim, 2010; Paolucci & Wessels, 2017). So, researchers should also carry out research in mixed-method designs.

41% of all research studies on mathematical modeling belonged to Turkey. The studies conducted in the U.S.A., Denmark, and South Africa corresponded to 21%. Other countries had just one study on mathematical modeling. Turkey's high percentage may be because curricula in Turkey clearly include mathematical modeling (Ministry of National Education, 2013; TTKB; 2013), and using mathematical modeling in the instructional processes is advised. The substantial increase in the number of studies on mathematical modeling in Turkey started in 2013 and the following years (Bayrak & Çiltaş, 2017; Çelik, 2017). This suggests that revisions in curricula, achievement or failure in international examinations, and changes in examination systems in countries may have led researchers to study mathematical modeling. On the other hand, curricula emphasized mathematical modeling as a basic competency in some countries such as Singapore (Ministry of Education Singapore, 2007) and Germany (The New German Educational Standards and Curricula, 2006). Yet, the countries are not among the countries included in our sample, indicating that changes in curricula do not affect countries' research trends in the same way. An examination of mathematical modeling studies carried out in Turkey, where most studies are published, shows that despite the increasing number of studies, there are not adequate studies addressing different levels, different components, and different methodologies. Therefore, researchers are advised to integrate mathematical modeling with other mathematical skills such as problem-solving, reasoning, and making associations. However, Çevikbaş et al., (2022) when the geographical regions of the studies were examined, it was determined that these studies were mostly conducted in Europe. While in our research, we almost did not find any research conducted in Germany, an interesting result was found by Çevikbaş et al. (2022) study found that researchers of German origin published more. This can be interpreted as the classification criteria related to mathematical modeling reflecting the research culture of the countries to some extent (Çevikbaş et al., 2022). Therefore, the classification criteria reveal such a result. For example, while mathematical modeling and mathematics education were used as the search terms in our research, the terms modeling competencies and mathematics were used in Çevikbaş et al., (2022)'s research.

Whether modeling was used as a goal or as a tool in modeling studies was also examined within the current study. Modeling was used as a tool in about 70% of the studies, which can be interpreted as that modeling studies paid regard to pedagogical purposes. In other words, studies prioritized forming contexts to teach mathematics in a more meaningful way (Kertil et al., 2016) rather than measuring modeling processes, modeling skills, and competencies. With the increasing use of technology in mathematical modeling activities, studies using modeling as a goal are expected to increase. Very few mathematical modeling studies examined within this study which adopted technology (Orey & Rosa, 2018) used modeling as a goal. The number of studies using modeling as a goal is expected to increase thanks to the increase in environments where students use technology for calculation in mathematical modeling education, they simulate the model in dynamic mathematics and geometry software, and they develop modeling competencies such as forming assumptions for the model, forming models, testing the assumptions and validating. However, in just a single study, pre-service teachers tried to solve a real-life problem in an interactive learning environment using dynamic mathematics software (Çekmez, 2020). Considering the contribution of technology to the development of mathematical modeling skills, mathematical modeling studies supported with technology employing digital materials would enrich the field.

The predominance of mathematical modeling as a tool approach within the research studies in the sample may be related to the fact that concept teaching is still maintaining its traditional place in the field. Particularly the approach of solving real-life problems for reinforcement after concept teaching (Doruk & Umay, 2011) led researchers to use mathematical modeling as a tool. Nearly half of the studies within the scope of the current study were carried out in a classroom setting, which may have also led to this result. Because studies that were not carried out in the classrooms of teachers who do not have adequate knowledge on modeling and modeling competency mostly used modeling as a tool. Teachers still regard mathematical modeling as the use of concrete materials and mathematical models as concrete objects (Gürbüz & Doğan, 2017). Modeling as a tool perspective is more common in studies in which researchers worked with teachers or pre-service teachers (Orey & Rosa, 2018; Dawn, 2018; Sevinç & Lesh, 2018). Considering that teaching modeling skills and strategies will increase in mathematical modeling education, more studies that aim to teach and develop students' mathematical modeling skills (Aztekin & Taşpınar-Şener, 2015) are needed. In addition, modeling as a goal perspective is used more with cognitive modeling approach (Şahin & Eraslan, 2016) and epistemological modeling approach (Frejd & Bergsten, 2016; Krutikhina et al., 2018; Urhan & Dost, 2017), and there were few studies adopting these approaches, which is in line with this finding. Studies adopting mathematical modeling as a goal should increase more because the increase in modeling skills and strategies will contribute to the development of students' modeling skills. Hence, studies towards the development of skills/competencies in the modeling process may contribute to better planning of this process and structuring the process. Further studies using mathematical modeling with approaches such as STEM grounding on interdisciplinary and multidisciplinary studies will help associate mathematics with different disciplines.

Although it was not possible to discriminate between modeling approaches used in the studies clearly, the studies that researchers agreed on were reported. The most challenging part for the researcher was because in most of the studies, how the activities of forming models were implemented was not explained sufficiently (Aztekin & Taşpınar-Şener, 2015). The most frequently used modeling approaches were educational modeling, realistic modeling, and epistemological modeling, respectively. Cognitive modeling and contextual modeling followed these approaches, respectively. That the predominant modeling approach in the studies was educational modeling led us to argue that studies in which learning processes are developed through modeling and particularly concept development is supported this way have gained a place in the modeling literature. In other words, the purposes of mathematics education, its instruction, and learning outputs are prioritized in the studies. In the studies adopting educational modeling approach, pedagogical purposes such as establishing pedagogical strategies (Galleguillos & de Carvalho Borba, 2018), designing and evaluating mathematical modeling activities (Dawn, 2018), and developing competencies of solving mathematical modeling problems (Chang et al., 2020) were featured. That the ratio of realistic modeling approaches that deal with the ability to use mathematics in solving real-life problems is in the second place among the examined studies can be interpreted as the studies on understanding the nature of modeling and improving modeling skills have begun to take place in the literature. That recently popularized issues such as STEM have been addressed in the few studies on the application of mathematics in different fields (engineering, astronomy, or physics) may have to do with the realistic modeling approach. It is noteworthy that cognitive modeling is used in few studies. A reason for this may be that these studies are primarily carried out with pre-service teachers, and they are limited to undergraduate education (Aztekin & Taşpınar-Şener, 2015). Besides, the sample size was mostly minimal in the studies adopting the cognitive modeling approach (Eraslan, 2012; Shahbari & Tabach, 2020; Şahin & Eraslan, 2016). This finding may be due to the fact that the cognitive model is based on the cognitive process, and metacognitive thinking processes are analyzed. For example, the participants of a study in which fourth-grade students' use of modeling activities and the challenges they experience were examined through cognitive and metacognitive thinking were three lower secondary school students (Eraslan & Kant, 2015). Further studies addressing cognitive modeling practices, or cognitive processes and challenges experienced during the modeling process, are needed for modeling studies to gain momentum. Another result of the current study is that limited studies included model forming activities that are considered within the contextual modeling approach (Paolucci & Wessels, 2017; Sevinc & Lesh, 2018). Increased studies on the design of particularly model-forming activities will guide practitioners on how to practice these activities in the classroom. One of the striking results in the study is that there were not any studies based on the socio-critical modeling approach. In particular, it may be suggested that researchers conduct studies on socio-critical modeling, which are based on an approach that can effectively use mathematical modeling to solve problems experienced in the world they live in or in their immediate surroundings.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

There is no conflict of interests.

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First author is responsible for conceptualization and methodology, second and third author is responsible for writing, reviewing, and editing.

Research involving Human Participants and/or Animals

When reporting studies that involve human participants, authors should include a statement that the studies have been approved by the appropriate institutional and/or national research ethics committee and have been performed in accordance with the ethical standards.

Matematiksel Modelleme Araştırmalarının İncelenmesi: Betimleyici Bir İçerik Analizi Çalışması

Özet:

Matematiğin gerçek yaşamdaki problemlerle ilişkilendirilmesi ve anlamlandırılmasında matematiksel modeller ve modelleme uygulamaları gün geçtikçe daha da benimsenir hale gelmiştir. Bu doğrultuda bir yetkinlik olarak geliştirilen matematiksel modelleme becerisi ise hem standartlar arasında hem de araştırmacılar tarafında yer edinmiştir. Özellikle matematik eğitiminde öğrenme ve öğretme süreçlerinde matematiksel modellemenin kullanımının anlaşılması bu çalışmaların geleceği için katkı sağlayacaktır. Bu araştırmada matematik eğitiminde modelleme çalışmalarına ilişkin eğilimlerin önde gelen çalışmalar üzerinden değerlendirilmesi amaçlanmıştır. Web of Science veri tabanında indekslenen araştırmalarla yürütülen çalışmada 2000-2021 yılları arasındaki farklı türdeki araştırmaların modelleme çalışmalarını hangi yönleriyle ele aldığı incelenmiştir. Bu çalışmalarda kullanılan matematiksel modelleme yaklaşımlarının yanı sıra araştırmalar yıl, örneklem ve kullanılan yöntem gibi temel özellikleri bakımından ele alınmıştır. Araştırmacılar tarafından geliştirilen form üzerinden değerlendirilen çalışmalar yıllara göre bu çalışmalarda beklendiği gibi bir artış meydana geldiğini, öğretmen adayları ile çoğunlukla araştırmaların yürütüldüğünü göstermiştir. Ayrıca araştırmada modelleme sürecinin yakından izlenmesi amacıyla çoğunlukla daha küçük araştırma grupları ile çalışmaların yürütüldüğü görülmüştür. Eğitsel modelleme ve gerçekçi modelleme yaklaşımlarının incelenen araştırmalarda öne çıkan modelleme yaklaşımları olduğu görülmüştür. Araştırma sonuçları, öğrencilerin sorumlu vatandaş olabilmeleri ve toplumsal gelişmelere katılım sağlayabilmeleri için bir yetkinlik olarak görülen modelleme becerisine ilişkin çalışmaların literatürde halen sınırlı bir yer tuttuğunu göstermiştir.

Anahtar kelimeler: matematiksel modelleme, matematik, modelleme, matematik eğitimi, betimsel içerik analizi

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Note. The studies included in the content analysis are marked with asterisks (*)

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Research Article

Adaptation of "Trust in Science and Scientists Scale" into Turkish: Validity-Reliability Study*

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Abstract- This study investigates the validity and reliability of the scale which was obtained by adapting the "Trust in Science and Scientists Inventory" developed by Nadelson et al. into Turkish simplified for middle school students to understand. As a result of the Exploratory Factor Analysis, the total variance accounted for by the two-factor scale containing a total of 16 items was found 57.442%. Cronbach α values were used to calculate the internal consistency of the factors (0.928 and 0.814, respectively). The Cronbach α internal consistency coefficient for the whole scale was calculated as 0.822. Then, Confirmatory Factor Analysis suggested that the two-factor model was compatible with the data. The results of the study show that the scale adapted into Turkish is a valid and reliable educational measurement tool for middle school students.
Key words: trust, trust in science, trust in scientists, scale adaptation.

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Introduction

Science is a cognitive quest to find the truth and explain the phenomenal world: It is a process of trial and error based on the criterion of consistency and error clarification (Yıldırım, 1999). This process involves the formation, accumulation and interpretation of scientific knowledge. The journey of science begins with thinking and curiosity. Scientists generate knowledge through observation and experimentation to understand what is happening around them. This information is tested with other experiments, observations and ideas. Weak hypotheses are discarded and the views that best align with the evidence with evidence are strengthened, thus advancing science.

Trust in science refers to public confidence in scientists and their work, which produces knowledge with meaningful implications for people's future well-being. People who are not engaged in science have limited knowledge/understanding of science, and therefore they trust or distrust science (European Federation of Academies, 2019). The formation of trust in science in society enables scientific knowledge to gain function in daily life. In other words, applying science is closely related to people's trust in science and scientists. A sense of trust in science can help people think critically (taking science into account) when making decisions and acting in all aspects of their lives. It is one of the possible ways if people understand how scientific knowledge is produced and how science works.

Trust significantly influences the perception of science-related topics (Dunn & Schweitzer 2005; Romano, 2003) such as genetically modified foods (Broughton & Nadelson, 2012), climate change (Dunlap & McCright, 2011), vaccines (Keelan et al., 2010) and potentially biological evolution (Smith et al., 1995). Increasing students' trust in science is considered as an important target in teaching socio-scientific issues (Sadler et al., 2007). Without trust in science, societies and governments are in danger of making decisions based on (partially) informed opinions and not on scientific evidence (European Federation of Academies, 2019). Societies that do not trust science cannot develop in areas such as medicine, technology and education that improve the quality of life.

The literature review shows that science is facing a crisis of public trust (Ertürk, 2018; Weingart, 2002; Cobern et al., 2022; Rowland et al., 2022). It is thought that controversial issues such as different comments by scientists about natural disasters after the earthquake in Turkey in February 2023, anti-vaccination sentiment, which reappeared on the agenda with the COVID-19 pandemic, and the impact of human and economic factors on climate change reduce people's trust in science and scientists. Considering the rational and objective dimensions of science, as well as those including value judgment, creative fantasy, and even sensuality (Yıldırım, 1999), there may be many concepts affecting trust/distrust in science.

The ever-evolving, unlimited, multifaceted and wide-ranging nature of science (Soslu, 2021) has brought controversial issues to the agenda. Examples include technology and space exploration, evolution, climate change, the use of energy resources, and whether vaccines are effective and safe. Differences of opinion among scientists, especially on socio- scientific issues, have affected the public trust in science and scientists. For example, after the earthquake in Turkey on February 6, 2023, which caused great loss and reminded Turkey of the reality of disasters, the robustness of buildings was discussed, and different comments by scientists regarding the predicted Istanbul earthquake drew attention. When scientists put forward different opinions on similar issues, it may undermine public trust (Ertürk, 2018). In this case, it would be useful to help the public understand the origins of differing opinions and how they can work.

Due to the nature of science, disagreements are likely to occur because scientists may focus on different samples and aspects when working on the same topic, or their ability to interpret scientific data may vary due to their experience. We can think of this diversity as richness, like the variation in biology that occurs when different genes are combined to protect against diseases carried by recessive genes. Changing perspective is like interpreting the same painting differently. Where you look from changes the picture you see.

In solving complex problems, new and creative ideas can be generated through interdisciplinary collaborative studies by bringing together scientists with different areas of expertise who can examine problems from different perspectives (Weeks et al., 2004). There are many examples of the drastic impact of collaboration, such as the successful development of the human papillomavirus vaccine and the discovery of the causative agent of severe acute respiratory syndrome (Abraham, 2004; Kreimer et al., 2011). Productive scientific work environments can be established through collaboration and cooperation. The power that holds a productive team together is that team members work honestly and openly and trust each other. Bennett et al. (2010), while describing the characteristics of an effective team, emphasize the importance of trust among team members and argue that it is necessary to support differences of opinion in case of disagreement.

Another concept that we think can reduce trust in science is information pollution (info pollution). Science reaches society through different communication channels such as education, schools, scientific publications, internet, television and media. The advancement of science and technology has increased human-induced risks, and such increased risk has led to distrust in general, which has shaken people's trust in science (Ertürk, 2018). Today, with the discovery of the ability to store information and the power of the internet, access to information has become much easier. However, it has gained importance to distinguish the correct and useful information from the rest. Similar to going blind when exposed to too much light, it may be possible for excessive stimuli can devalue or render a stimulus unrecognizable. In addition, the risk of info pollution due to false statements may reduce trust as information can be shared on the internet without being censored. What is important is that people need to learn how to access reliable information by evaluating their information sources. For this reason, they should be taught critical thinking skills and scientific literacy. Critical thinking and science literacy play an important role in the process of finding reliable information. Critical thinking is a way of thinking that includes skills that require questioning. Science literacy is the ability to understand and apply the scientific method. These skills help individuals to distinguish misleading information in the process of finding reliable information (Kurt & Kürüm, 2010).

The 2002 report of the European Molecular Biology Organization (EMBO), which was founded in 1964 by the leading scientists of Europe in the field of Life Sciences, includes views on how science can produce and communicate reliable information. Weingart (2002) mentions three major problems that can undermine trust in scientific authority, which are the growing influence of politics on science, the increasing commercialization of science, and scientists using the media to gain public support for their research. The report describes examples of changing perspectives on science and scientists as a result of the close interactions between science, politics and the media. It mentions that some groups invite scientists to public hearings to protect their positions and interests in politics and economics and that scientific expertise is used to prove the views of the parties on issues such as nuclear energy, vaccines, biotechnology in agriculture, the relationship of the Genome Project with ethical values and economics, which causes the public to question the trust in science. On the other hand, it argues that scientists must use the media to find funding for their research and that the current system compels them to provide commentary on finding solutions to various issues or cures for different diseases to draw attention to their studies.

As the COVID-19 pandemic continues to affect the world, there has been an increase in the number of people who are against vaccines due to concerns such as potential side effects of vaccines and concerns about possible long-term damage to the body caused by the substances contained in them (Ataç & Aker, 2014). In February 2020, the Director- General of the World Health Organization warned the public that we were facing an "infodemic" of conspiracy theories generated by the circulation of many false news about the pandemic and the rapid spread of these news (Akkurt, 2022). Infodemic can be defined as information overload that invariably includes false or unreliable information, people's inability to access reliable and accurate information, and the rapid spread of prejudice and misinformation (Gölbaşı & Metintas, 2020). At this point, one should not believe every piece of information. Blindly trusting without questioning is as risky as distrusting science, as both prevent critical thinking. Students should learn to distinguish when to question emergent and uncertain scientific contexts and when and why one should place trust in science (Bryce & Fraser, 2014; Fensham, 2014).

Cobern et al. (2022), in their study of the reliability of science with about 500 undergraduate students studying teaching at a Midwestern State University, concluded that most students accepted science as unquestionably true and that almost all of them acknowledged the tentative nature of science, regardless of what they thought about controversial issues. However, they found that many students were not willing to say that they trusted scientific knowledge. When students were asked why science was not trustworthy, the common response was that scientific knowledge is subject to change and revision. As a requirement of science, it should be accepted that new views are suggested over time, that previously established truths may change in the light of new data, and that should not be considered as "contradictions" (Badur, 2021).

Covitt and Anderson (2022) distinguish uncertainty from unreliability. They argue that a critical goal of science education is to teach students that science is uncertain and limited, as well as how it can be used as a helpful tool for making decisions about socio-scientific issues. Resolving uncertainties in science, making sense of uncertainties and conducting research to address them contribute to the development of science. It is essential to raise individuals who believe in the capacity of science in solving problems such as environmental pollution, destruction of natural areas through concretion, global warming, drought, protection of biodiversity, and who think, take responsibility, do not harm the environment and strive to be citizens who are science literate.

While the issue of trust remains on the agenda, there is a need for scales to measure trust in science and scientists. When Nadelson et al. (2014) reviewed the literature on trust in science, they realized that there was no scale to assess students' trust in science and introduced the Trust in Science and Scientists Inventory. The Trust in Science and Scientists Inventory scale has been previously used by six researchers: Nadelson and Hardy (2015) examined the relationship between trust in science and scientists and acceptance of evolution; Kingsley and Van Kranendonk (2017) investigated the impact of science teaching through social activities on students' understanding, attitudes and perceptions of science; Blankenship and Stewart (2019) reviewed the themes of gender and identity in the context of voting and trust in the 2016 presidential election in the USA; MacDonald et al. (2020) used it in their study on public opinion on the practice of controlling insects for the protection of biodiversity; Krüger et al. (2022) selected and applied certain items of the "Trust in Science and Scientists" scale developed by Nadelson et al. (2014) while measuring the level of trust in science among secondary school students (average age 17) in Germany; and finally, Esen and Alkış Küçükaydın (2022) made the adaptation study of this scale for undergraduate students in Turkey. Nadelson et al. (2014) recommended that in future studies, necessary adjustments should be made to ensure the use of this scale they developed with students at different educational levels. Responding to this call, we aim to adjust the relevant scale at the level of middle school students as we believe that the trust developed in childhood can affect decision-making behaviors in adulthood.

In Ericson's theory of psychosocial development, the first of the eight developmental stages that people experience is a sense of basic trust versus distrust. The first step to reach the other developmental stages for a healthy state of mind is to acquire a sense of basic trust, which enables people to have a positive sense of self. Individuals with high self-perception have realistic expectations from the future. They stick by their decisions and ideas, take responsibility and assume the consequences of events (Çam et al., 2017). It can be a key step to reveal both the current status and the variables affecting trust in science to measure middle school students' trust in science as well as self-confidence in middle school ages, where self-perception is shaped. In this context, our study aims to evaluate the validity and reliability of the scale developed by Nadelson et al. (2014) for undergraduate students by simplifying and adapting its original version in English (Trust in Science and Scientists Inventory) to Turkish in a manner understandable for middle school students. Esen and Alkış Küçükaydın (2022) have adapted this scale into Turkish for use in studies with pre-service teachers. The most significant difference between our study and theirs is the sample group. The scale has been adapted for use at the middle school level.

Nadelson et al. (2014) pointed out that the original scale they developed, targeting undergraduate students, might be limiting for subsequent studies. They suggested that necessary adjustments be made for future studies to ensure the applicability of the scale to students at different educational levels. They emphasized the need to test the suitability of the scale for students from primary school to secondary school, simplifying some parts of the language used in the scale to align with the experiences of K-12 students and their level of knowledge. The sample of the study was determined by taking into account the authors' suggestion, and through the pilot implementation, the scale was simplified to match the age, knowledge, and experiences of the students. Explanations for two terms that students found unfamiliar in the scale were added to the beginning of the scale as a mini-dictionary. All these measures set our study apart from others.

In the context of uncovering factors influencing trust, Esen and Alkış Küçükaydın (2022) have proposed revealing the relationship between the trust of different age groups in science and scientists and their ideological structures. Considering these suggestions, it is believed that adapting the scale to different age groups will contribute to the field.

In this context, the following questions were sought to be answered in our study.

During the adaptation of the Trust in Science and Scientists Inventory into Turkish,

a) Has linguistic equivalence been achieved between the Turkish version and the original?

b) What is the factor structure of the Turkish adaptation of the scale?

c) Does the measurement model with factor structure fit the data?

d) Is the adapted scale a valid and reliable one that can be used in the field of education?

Method

In this study, we aimed to conduct validity and reliability studies of the Turkish version of the Trust in Science and Scientists Inventory. Considering the previous studies on the scale we were working on, we understood that some items were chosen and applied without assessing the overall structural validity in prior applications of the scale. For this reason, it was found necessary to first investigate the structure of the scale. There are basically two approaches in factor analysis. The first one is "Exploratory Factor Analysis (EFA)", which aims to reveal and discover the factor structure underlying the statements representing the variables of a newly developed or translated scale. The other one is "Confirmatory Factor Analysis (CFA)", which checks the conformity of a previously employed scale to the original factor structure when used in the current research (Suhr, 2006). In our study, exploratory factor analysis was first applied to determine the scale structure and then CFA to test the compatibility of the structure with the data. SPSS 15.0 and AMOS 22.0 programs were used in the statistical procedures.

Study Sample

The sample of this study consists of student groups studying at the fifth, sixth, seventh and eighth grade level of middle school in the academic year of 2022-2023. These groups include 20 students with whom we conducted a trial application of the scale translated into Turkish, 16 students with whom we tested the linguistic equivalence of the translated text, 290 students with whom we obtained exploratory factor analysis data, and finally 298 students for confirmatory factor analysis. The groups were determined by convenience sampling method. It refers to a process that starts from the most accessible participant and continues until it reaches the required size or all participants who can be reached in the available period (Cohen et al., 2007). While defining the sample size, the rule of at least 10 participants for each variable (Cohen & Cohen, 1983) was taken into consideration. Text begins as a new paragraph.

Data Collection Tool

In this study, the "Trust in Science and Scientists Inventory" developed by Nadelson et al. (2014) for undergraduate students was adapted into Turkish by simplifying it to be convenient for middle school students. The original scale has a unidimensional structure (Cronbach's alpha 0.86) consisting of a total of 21 items (9 positive and 12 negative) on a five point likert type. The "Trust in Science and Scientists Inventory" scale has been previously used in different forms by six researchers:

- Nadelson and Hardy (2015), in their study investigating the relationship between trust in science and scientists and acceptance of evolution, used the unidimensional "Trust in Science and Scientists Inventory" scale consisting of 21 items (α = .86)

- Kingsley and Van Kranendonk (2017), in their study measuring the effect of science education on science understanding, attitudes and perceptions through social activities they designed, selected 11 items from the "Trust in Science and Scientists Inventory" scale and applied them in five point likert type.

- Blankenship and Stewart (2019), in their study reviewing the themes of gender and identity in the context of voting and trust in the 2016 presidential elections in the USA, used a seven point likert-type measurement tool that they created by selecting 10 items from the "Trust in Science and Scientists Inventory" scale (α = .92).

- MacDonald et al. (2020) used six items selected from the "Trust in Science and Scientists Inventory" scale on a seven point likert type in the trust aspect of their study in which they investigated public opinion on the practice of controlling insects for the protection of biodiversity.

- Krüger et al. (2022) wanted to use the 21-item "Trust in Science and Scientists Inventory" scale developed by Nadelson et al. (2014) in their study investigating the level of trust in science among secondary school students (average age 17) in Germany, and adapted the scale, which is valid and reliable at the level of undergraduate students, to the German language at the secondary school level. They pointed out that the scale was previously applied by selecting certain items without testing its general content structure, and therefore they investigated the construct validity of the scale. They determined that the scale had a two-dimensional structure and preferred to use the factor consisting of items 7, 9, 10, 11 and 12 of the original scale in a five point likert type and did not mention the information of the other factor they found.

- Esen and Alkış Küçükaydın (2022) made the adaptation study of this scale for undergraduate students in Turkey. They found a two factor structure consisting of 10 items after the adaptation. They named these factors "trust in science" and "trust in scientists".

Stages of Adapting the Data Collection Tool into Turkish

The study was initiated after encountering the "Trust in Science and Scientists Inventory" as a result of the literature review conducted after the awareness of the importance of trust in science. In order to translate this scale into Turkish, firstly, the author Nadelson was contacted via e-mail and the necessary permissions were obtained from him for the adaptation of the scale. In addition, ethics committee approval was obtained first from the institution to be applied and then from the institute of educational sciences of a university to apply the scale to students during and after the adaptation phase. During the translation of the scale into Turkish, the reverse translation method was used. A translation team consisting of language and field experts was formed to translate the scale, whose original version is in English, into Turkish, the target language. The team members and the procedures performed are as follows:

1) The team includes four experts in English: Two specialized English teachers working in a high school and a middle school affiliated to the Ministry of National Education, a graduate student from a university providing education in English, who is doing their PhD in the US, and a translator who also graduated from the same university

2) The team had three linguists in the field of Turkish: A faculty member working in the Department of Turkish Education and two specialized Turkish teachers working in a middle school affiliated to the Ministry of National Education.

3) The team had two Science experts: A faculty member working in the Department of Science Education and an expert science teacher working in a middle school affiliated to the Ministry of National Education.

First, three English language experts independently translated the original scale into Turkish. The three translations obtained were reviewed by Turkish language experts, and it was checked whether there were any differences in meaning in these translations, and all three translations were found to be close to each other. Turkish language experts came together to determine the sentences that most clearly and fluently described the statements in the scale. At this point, the opinions of science experts on language and content specific to the field were also taken into consideration, and thus the draft scale was established. The draft scale was also checked by language experts in terms of punctuation marks and adjusted as needed. Its face and content validity were ensured as a result of the arrangements made by taking expert opinions into consideration and it was applied to a total of 20 students (10 male and 10 female), five students from each of the fifth, sixth, seventh and eighth grade levels, and the students were asked to indicate any expressions they had difficulty understanding. According to the feedback received from the students, it was found that the students did not know the meaning of two scientific terms (hypothesis and theory) and one word (ethics). In addition, it was noticed that using synonyms of words in some expressions would make it easier for students to understand them (For example, the expression "go against" was preferred instead of "contradicting"). Based on the trial application, a glossary was added to the introduction of the scale and three words (hypothesis, theory and ethics) that the students did not know were briefly explained. During the preparation of the glossary, help was obtained from science experts in explaining the words that have the meaning of scientific terms. The terms were explained in the simplest form suitable for middle school students. After the necessary adjustments were made, the final version of the scale was translated back into English, the original language of the text, by a translator, and the reverse translation was compared with the original scale by foreign language experts, and it was seen that there was no difference in meaning between the two. Finally, the Turkish text and the original scale were applied to 16 middle school students who were fluent in both English and Turkish at three-seven-day intervals and the correlation between the findings was analyzed. Thus, the linguistic equivalence of the scale was tested and the translation into Turkish was finalized. The Turkish version of the "Trust in Science and Scientists Inventory" scale is a five-point Likert-type scale consisting of a total of 21 statements, 12 negative and 9 positive, as in the original scale. The scale, again as in the original, includes "Strongly Disagree", "Disagree", "Neutral", "Agree" and "Strongly Agree" options indicating the degree of agreement/disagreement with the attitude object covered by the statements.

Data Collection

The adapted version of the scale was applied online to 290 middle school students during the 2022-2023 academic year via a Google Form Application over a period of four weeks. The scale structure, derived from the exploratory factor analysis results, was also administered to 298 students using the same method.

Data Analysis

The Turkish scale was used in a five point likert type as in the original scale. The students in the group participating in the study marked one of the options "Strongly Disagree", "Disagree", "Neutral", "Agree" and "Strongly Agree" for the statements in the scale, thus reporting their degree of agreement/disagreement with the attitude object covered by each statement. Scoring of the scale items is as follows in Table 1.

Table 1 Scoring Key of the Items in the Adapted Scale

Option	Positive Statement Score	Negative Statement Score
Strongly Disagree	1	5
Disagree	2	4
Neutral	3	3
Agree	4	2
Strongly Agree	5	1

The score a student gets from the scale is the sum of the scores they get from the items in the scale. Since the scale we are working on consists of 21 items, the range of points that students can get from the scale will be between 21 and 105.

Findings

Linguistic Equivalence

In the process of quantitatively reviewing linguistic equivalence, it is necessary to reach a sample group that is fluent in both the target and source languages to make statistical applications (Seçer, 2015). The original form and the Turkish form were applied to 16 middle school students who were found successful in English and Turkish lessons by their teachers at their schools, with an interval of three to seven days. Then, a paired samples t-test was conducted to determine whether there was a significant difference between the total scores in the measurements obtained from the applications. The rank difference correlation coefficients and t-test results calculated over the item total scores for the forms in different languages are given in Table 2. In this section, research findings should be explained by benefiting from related literature.

Table 2 Total Score Statistics from Turkish and English Forms

Paired Sample Statistics					
		Mean	*N*	Standard Deviation	Mean of Standard Errors
Pairing 1	Turkish	80.5000	16	10.17186	2.54296
	English	79.3125	16	10.26138	2.56534

Paired Samples Test Paired Differences				95% Confidence Interval for the Difference				
	Mean	Standard Deviation	Mean of Standard Errors	Upper	Lower	*t*		*p*
Pairing 1 Tr- Eng	1.18750	6.99732	1.74933	-2.54111	4.91611	.679	15	.508

According to Table 2, the mean scores, standard deviation and error values of the forms in different languages were remarkably close to each other. A high correlation was found between the total scores obtained from the forms (r: 0.765). There was no significant difference between the arithmetic averages ($p>0.05$). Based on these data, it was accepted that linguistic equivalence between the original form and the translation was achieved.

Normality Analysis of Data Set

One way to check whether the distribution of data conforms to the normal curve is simply to create a histogram and look at the overall shape of the distribution. Another way is to perform skewness and kurtosis tests or a general test that measures the normality of the distribution, such as the Shapiro-Wilk and Kolmogorov-Smirnov tests (Cohen et al., 2021). The normality analysis of the 290 sets of data to be used in the exploratory factor analysis was carried out in four stages:

1. Analysis of skewness and kurtosis values,
2. Dividing skewness and kurtosis values by standard error,
3. Checking extreme values,
4. Performing Shapiro-Wilk and Kolmogorov-Smirnov tests.

In normal distributions, the measures of skewness and kurtosis are zero. In positive sciences, it is possible for data to show a normal distribution. However, especially in social sciences and educational research, it is accepted that these values are close to zero. As these values move away from zero, so does the distribution from normality. For a distribution to be "normal" at an acceptable level, skewness and kurtosis values should be between -1.00 and +1.00 (Büyüköztürk et al., 2011; Hair et al., 2013).

Table 3 Distribution of Data

Data	**Statistics**	**Standard Error**
Skewness	-.192	.143
Kurtosis	.174	.285

According to Table 3, the skewness (-.192) and kurtosis (.174) values of the data are in accordance with the normal distribution. The other condition for a normal distribution is that the value found by dividing the skewness and kurtosis values by the standard error should be between -1.96 and +1.96 (Büyüköztürk, 2015). Accordingly, when Table 3 is analyzed, the values found (-0.192: 0.143= - 1.342; 0.174: 0.285= 0.61) show that the data have a normal distribution. When the extreme values were checked (histogram, graph showing deviations from normal and box plot), it was understood that a data with the lowest score value was an extreme value.

Table 4 Normality Analysis Test

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistics	df	Sig.	Statistics	df	Sig.
Total	.046	290	.200*	.993	290	.193

The normality analysis test results applied to the data set are as shown in Table 4. Shapiro-Wilk test when the group size is smaller than 50 and Kolmogorov-Smirnov (K-S) test when the group size is larger are the two tests used to analyze the normality of the scores. Since the statistical null hypothesis in the analysis is "the distribution of the scores does not differ significantly from the normal distribution", a p value greater than .05 is interpreted as the scores do not deviate significantly (excessively) from the normal distribution at this significance level and are in conformity (Büyüköztürk, 2015). Here, the p value in the Kolmogorov-Smirnov test is greater than .05 (p= .200> .05). When the Kolmogorov-Smirnov test result, skewness and kurtosis values and the graphs drawn were interpreted, it was understood that the data set met the normal distribution criteria. For this reason, it was deemed appropriate to conduct exploratory factor analysis without removing the extreme value found from the data set.

Construct Validity

The construct validity of the Trust in Science and Scientists Scale Inventory was reviewed. In order to decide whether the data were fit for factor analysis, Kaiser- Meyer-Olkin (KMO) coefficient was calculated, and Bartlett's test of sphericity was applied. Furthermore, to conduct factor analysis, the KMO coefficient must be greater than 0.60 and Bartlett's test of sphericity must be significant ($p<0.05$) (Cohen et al., 2021).

Table 5 Data on the Suitability of the Scale for Factor Analysis

Kaiser-Meyer-Olkin (KMO) Sample Measurement Adequacy		.895
Bartlett Test	Chi-Square Value	2400.356
	df	120
	Sig. (p value)	.000

In Table 5, the KMO coefficient value is 0.895, which indicates that the sample size is sufficient for principal component analysis. When the KMO value is calculated as 0.80 and above, sampling adequacy is interpreted as excellent (Sipahi et al., 2006; Nakip, 2006). The result of Bartlett's test of sphericity is significant ($x^2_{(120)}$ =2400.356; $p < 0.05$).

Factor analysis is used to see whether the items in a scale are divided into fewer factors that exclude each other, that is, for item reduction. Thus, the items measuring the same factor are gathered together and the group formed is given a name based on the content of the items (Balcı, 2022). During the analysis, if there is a correlation between the factors, the oblique rotation method should be selected, and if the factors are not related, the orthogonal rotation method should be employed (Güngör, 2016). In this study, Direct Oblimin method, one of the oblique rotation methods, was used in principal component analysis since the factors were thought to be related.

Each factor is expected to account for at least 5% of the total variance in the scale (Seçer, 2015). Kaya (2013) suggests that in cases where an item shows strong correlation in more than one factor, items with a difference of less than 0.10 between two factors should be removed from the scale. Based on this information, when the overlapping items (items 3, 4, 8, 13 and 18) were removed from the scale, it was seen that the items were grouped under two factors that complied with the rule of accounting for at least 5% of the total variance. Factors have an eigenvalue which is found by summing the squares of the loads of all variables on each factor. Factors with an eigenvalue greater than 1 are considered significant (Yaşlıoğlu, 2017). The Scree Plot graph generated shows the eigenvalues. Figure 1 indicates that the scale items are grouped under two factors with eigenvalues greater than one.

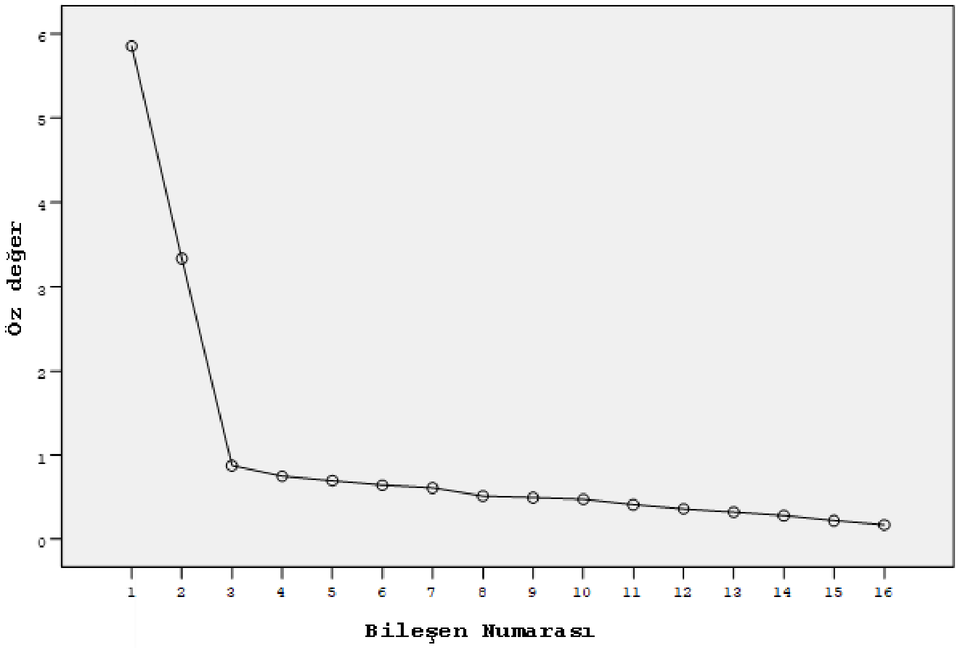

Figure 1 Scree Plot Graph

When the results of the Exploratory Factor Analysis (EFA) were interpreted in the scree plot, it was determined that the first sub-factor of the measurement tool consisted of nine items (10, 9, 11, 16, 15, 7, 14, 12, 5) and the second sub-factor seven items (20, 17, 21, 6, 2, 19, 1), totaling 16 items (Appendix 1). When the sub-factors were analyzed, it was understood that all nine items under the first factor were positive statements, and all of the second factor items were negative statements. For this reason, the first factor was named "Trust" while the second factor was named "Distrust".

Table 6 Factor Structures of the Scale

Factor	Eigenvalue	Variance Percentage	Accumulated Percentage	Cronbach α
1	5.857	36.608	36.608	.928
2	3.333	20.834	57.442	.814
Scale Sum				.822

As shown in Table 6, the eigenvalue of the first sub-factor of the measurement tool was 5.857 and the variance accounted for was 36.608%, while that of the second sub-factor was 3.333 and the variance accounted for was 20.834%. It is an important criterion of factor analysis that this variance exceeds 50% of the total variance (Yaşlıoğlu, 2017). In conclusion, it was determined that the measurement tool accounted for 57.442% of the variance, which indicates a high rate. Factor loads are presented in Table 7. To improve the interpretability of the factors, items with factor loads > 0.647 were selected for factor 1 and > 0.539 for factor 2.

Table 7 Factor Loads of Scale Items

Items	Factors	
	1	2
m10	.864	
m11	.851	
m9	.848	
m15	.818	
m16	.817	
m7	.806	
m12	.756	
m14	.752	
m5	.647	
m17		.785
m20		.753
m21		.736

m6	.719
m2	.682
m1	.585
m19	.539

Reliability Analysis of the Scale

The reliability of the scale was calculated through Cronbach's α reliability coefficient applied to the entire scale and each sub-factor. An internal consistency coefficient of .70 and above indicates that the measurement tool is exceptionally reliable (Büyüköztürk et al., 2011). Table 6 shows that Cronbach Alpha coefficients represent a high level of internal consistency for the 16-item scale and its sub-dimensions. The internal consistency coefficient of the scale was alpha=.822. In addition, the internal consistency coefficient for the sub-factors was calculated as F1=,928 and F2=,814. These values show that the Trust in Science and Scientists Inventory scale is a reliable measurement tool with its two-factor structure.

Item Discrimination

The raw scores of the students were sorted from the highest to the lowest and the most successful 27% of the group were named as the "**upper group**" (high scorers) (n1=78). The least successful 27% of the group was labeled as "**lower group**" (low scorers) (n2=78). It was examined whether there was a significant difference between the scores obtained by the lower and upper groups from each item and the total of the test. Since the lower and upper groups in the whole test showed normal distribution, independent variables t-test analysis was performed over parametric statistics. It was determined that the t values for the differences between the item scores of the 27% upper and lower groups of the scale ranged between 4.705 and 11.133 and were significant (p<.01) (Table 8). A correlation coefficient between 0.70-1.00 is defined as a high-level relationship, between 0.70-0.30 as a medium level relationship, and between 0.30-0.00 as a low-level relationship (Büyüköztürk, 2015). Based on this information, it can be said that the item total correlations are at a moderate level.

Table 8 Item Analysis Results

Item	Group	Mean	Standard Deviation	Item Total Correlation *(n=290)*	*t*	*p*
m1	Upper (27%)	4.0385	1.07440	.376	4.873	.000
	Lower (27%)	3.1282	1.25210		4.873	.000
m2	Upper (27%)	4.3974	1.07316	.470	6.719	.000
	Lower (27%)	3.1154	1.29916		6.719	.000

m5	Upper (27%)	3.8077	.98109	.447	4.705	.000
	Lower (27%)	2.9103	1.36929		4.705	.000
m6	Upper (27%)	4.7692	.45365	.516	10.266	.000
	Lower (27%)	3.2179	1.25509		10.266	.000
m7	Upper (27%)	4.4872	.84889	.644	9.363	.000
	Lower (27%)	2.7949	1.35185		9.363	.000
m9	Upper (27%)	4.4103	.88912	.713	10.908	.000
	Lower (27%)	2.5641	1.20162		10.908	.000
m10	Upper (27%)	4.3462	.73550	.740	11.133	.000
	Lower (27%)	2.5000	1.26645		11.133	.000
m11	Upper (27%)	4.1667	.79637	.736	8.692	.000
	Lower (27%)	2.6795	1.28421		8.692	.000
m12	Upper (27%)	3.9103	.99591	.578	8.047	.000
	Lower (27%)	2.5256	1.14783		8.047	.000
m14	Upper (27%)	4.1410	1.11337	.574	7.908	.000
	Lower (27%)	2.6667	1.21320		7.908	.000
m15	Upper (27%)	4.2051	.87325	.665	9.290	.000
	Lower (27%)	2.5897	1.26323		9.290	.000
m16	Upper (27%)	4.3333	.87782	.667	9.598	.000
	Lower (27%)	2.5897	1.34296		9.598	.000
m17	Upper (27%)	4.6923	.60961	.610	10.490	.000
	Lower (27%)	2.9615	1.32354		10.490	.000
m19	Upper (27%)	3.9103	1.23988	.355	5.346	.000
	Lower (27%)	2.8974	1.12342		5.346	.000
m20	Upper (27%)	4.4231	1.00025	.562	8.518	.000
	Lower (27%)	2.8590	1.27640		8.518	.000
m21	Upper (27%)	4.6538	.89482	.537	8.843	.000
	Lower (27%)	3.1026	1.26481		8.843	.000
Total	Upper (27%)	85.6795	4.56837	1.00	30.753	.000
	Lower (27%)	60.2692	5.69044		30.753	.000

Unlike the data used in the exploratory factor analysis, data were collected from 298 students to confirm the predicted two-factor structure of the scale. Confirmatory factor analysis was performed on the data obtained with IBM AMOS 22 package program. First, the distribution of the data was analyzed. When calculation methods that require normality assumption (maximum likelihood) are used, the data should show normal or near-normal distribution. According to Gürbüz (2021), while the normal distribution of the data is accepted in Structural Equation Modeling (SEM) with a multiple kurtosis critical value below 10, it does not pose a problem up to 20. The multiple kurtosis critical value of the study data was calculated as 19.134. Since the data were close to normal distribution, maximum likelihood calculation method was used. The goodness of fit values calculated as a result of CFA and the threshold values of these indices accepted in the literature (Schumacker & Lomax, 2004; Hu & Bentler, 1999; Sümer, 2000; Thompson, 2004; Kline, 2016) are given in Table 9.

Table 9 Goodness of Fit Indices and Threshold Values for CFA

Index	Good Fit	Acceptable	Study Values
X^2 (CMIN): Chi-Square	p>.05	should be (insignificant)	285.802 p: 0.00
X^2/df: Normed Chi-Square	≤3	3 ≤X^2/df ≤5	2.775
RMSEA: Root Mean Square Error of Approximation	≤.05	≤.08	.077
SRMR: Square Root of Standard Mean Error	≤.05	≤.08	.095
CFI: Comparative Fit Index	≥.95	≥.90	.942
NFI: Normed Fit Index	≥.95	≥.90	.913
NNFI (TLI): Non-Normed Fit Index	≥.95	≥.90	.933
IFI: Incremental Fit Index	≥.95	≥.90	.942
GFI: Goodness of Fit Index	≥.95	≥.90	.891
AGFI: Adjusted Goodness of Fit Index	≥.95	≥.90	.855

In order to ensure a good fit between the proposed model and the data, the X^2 value is expected to be insignificant. However, it is accepted that the quotient of this value to the degrees of freedom (X^2/df) is more accurate in evaluating the goodness of fit of the general model (Güngör, 2016; Gürbüz, 2021). In cases where the X^2 value, which is sensitive to sample size, is significant, the X^2/df ratio being less than five is seen as an indicator of fit (Sumer, 2000; Hooper, Coughlan & Mullen, 2008; Kline, 2011). Table 9 shows that the X^2/df value obtained as a result of CFA is significant (X^2=285.802, df=103, p=0.00). It is seen that the X^2/df ratio is excellent and the RMSEA, CFI, NFI, NNFI, IFI indices are within the limits of good fit.

Although the GFI (.891) and AGFI (.855) indices are slightly below the goodness of fit limit, it can be stated that the model-data fit is achieved as they are remarkably close to the limit value and when the obtained indices are evaluated. The standardized coefficients -path diagram- obtained as a result of CFA are given in Figure 2.

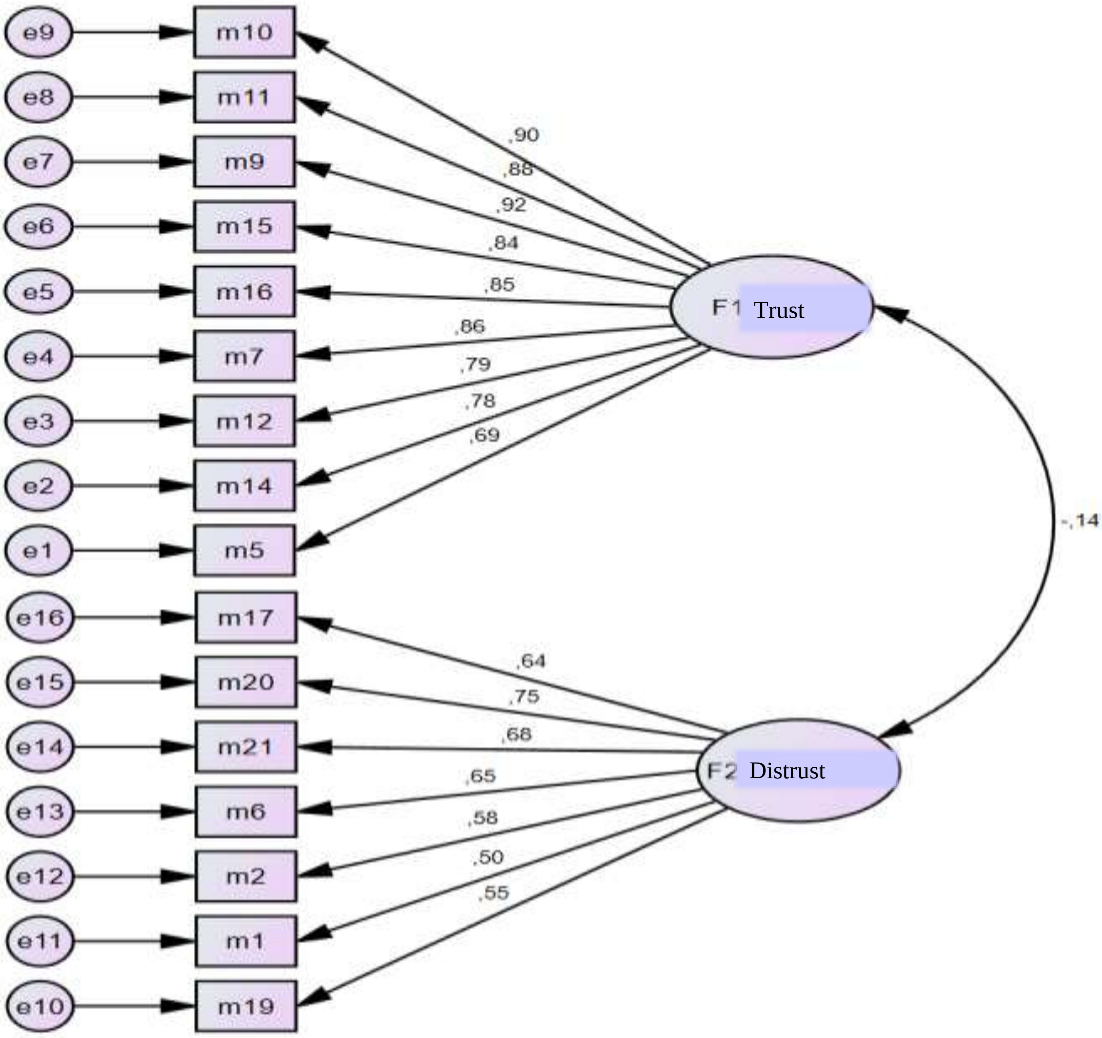

Figure 2 Standardized Coefficients of the Scale

In an ideal Structural Equation Modeling, factor loads are expected to be high (>.50) and correlations between factors do not exceed .85 in multi-factor models (Gürbüz, 2021). Figure 2 shows that the factor loadings range between .69 and .92 for the "F1: Trust" sub-dimension and between .50 and .75 for the "F2: Distrust" sub-dimension. It is seen that the correlation between the two factors in the proposed model is .14. All these values indicate that the data are compatible with the model.

Discussions, Conclusions and Suggestions

In this study, the validity and reliability of the Turkish adaptation of "Trust in Science and Scientists Inventory" ("Bilime ve Bilim İnsanlarına Güven Ölçeği") developed by Nadelson et al. (2014) was investigated. The appearance, content and construct validity of the scale were analyzed for validity, and item-total test score correlation and internal consistency coefficients for reliability. The construct validity of the scale was tested with exploratory and confirmatory factor analyses. First, linguistic equivalence between the Turkish form of the scale and the original was ensured. Exploratory analysis which aims to find the factor structure of the scale revealed a 2-factor structure and whether this structure is valid in Turkish culture was tested by confirmatory factor analysis. It was seen that the positive and negative items of the scale were grouped under two separate factors and the positive factor was named "Trust" and the negative factor "Distrust". The factor loads of the items gathered under the "Trust" factor are higher than those of the items under the "Distrust" factor. This is thought to be since students understand positive items more easily than negative ones. In their study investigating middle school students' trust in science, Krüger et al. (2022) concluded that the scale we adapted had two different dimensions in German culture and continued their research by using only the part of these dimensions containing positive items and did not provide information about the negative one. At the end of our study, both factors were found valid and reliable (Cronbach α_{trust}: 0.928 and Cronbach $\alpha_{distrust}$: 0.814). The 2-factor structure of the scale supports the findings of Krüger et al.

The Cronbach's Alpha reliability coefficient calculated for the entire scale is 0.822. A high internal consistency coefficient (0.822) indicates that the scale items are consistent with each other. The t-test results between the item mean scores of the upper 27% and lower 27% groups for the item discrimination showed that the differences were significant for all items. The adapted scale can distinguish between those that have the property to be measured and those that do not. The total variance accounted for by the final scale consisting of 16 items was found to be 57.442% (36.608% for the first factor and 20.834% for the second factor).

Compared to the study of Esen and Alkış Küçükaydın (2022), fewer items were removed from the original scale and the total variance explained by the scale was calculated higher. The factor structures found are also different. Different from our study, Esen and Alkış Küçükaydın (2022) named the two factors they found as "trust in science" and "trust in scientists".

The study findings show that the Trust in Science and Scientists Inventory (Appendix A) adapted into Turkish is a valid and reliable scale that can be used in the field of education for middle school students. In future studies, validity and reliability of the scale can be investigated in larger sample groups.

Ertürk (2018) suggests that trust in science can be improved through a humanistic approach. Krüger et al. (2022) state that it would be useful to investigate which factors have an encouraging effect on the development of trust during school years. The adapted scale can be used to middle school students to investigate students' trust in science and scientists. Studies that are unique and require active participation of students can be organized to help build this trust.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

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Research involving Human Participants and/or Animals

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Bilime ve Bilim İnsanına Güven Ölçeği'nin Türkçe'ye Uyarlanması: Geçerlik-Güvenilirlik Çalışması

Özet:

Bu çalışmada, Nadelson ve diğerleri (2014) tarafından geliştirilen "Trust in Science and Scientists Inventory"nin ortaokul öğrencilerinin anlayabileceği sadelikte Türkçe'ye uyarlanmasıyla elde edilen "Bilime ve Bilim İnsanlarına Güven Ölçeği"nin geçerlik- güvenirlik çalışması yapılmıştır. Açımlayıcı Faktör Analizi sonucunda toplam 16 madde içeren iki faktörlü ölçeğin açıkladığı toplam varyans %57,442 olarak bulunmuştur. Faktörlerin içsel tutarlılıklarının hesaplanmasında Cronbach α değerleri kullanılmıştır (bu değerler sırasıyla 0,928; 0,814). Ölçeğin tamamı için Cronbach α iç tutarlık katsayısı 0,822 olarak hesaplanmıştır. Ardından Doğrulayıcı Faktör Analizi yapılarak iki faktörlü modelin verilerle uyum gösterdiği belirlenmiştir. Çalışmanın bulguları Türkçe'ye uyarlanan ölçeğin, eğitim alanında ortaokul öğrencilerine yönelik geçerli ve güvenilir bir ölçme aracı olduğunu göstermektedir.

Anahtar kelimeler: güven, bilime güven, bilim insanlarına güven, ölçek uyarlanması.

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Appendix A: Trust in Science and Scientists Inventory

The meanings of the words marked with an asterisk on the scale are as follows:

*** Ethics:** In accordance with the code of ethics.

**** Theory:** Scientific views that explain an event with the help of observations and experiments.

Trust Factor

Original scale no.	Adapted scale no.	
10	1	We need to trust that scientists are honest in their work.
9	2	We need to trust the work of scientists.
11	3	We need to trust that scientists act ethically* in their work.
16	4	I trust that scientists can find solutions to our important technology-related problems.
15	5	We can rely on science for explanations of the natural life.
7	6	I trust that scientists make life better for us through their work.
14	7	People who understand science better trust science more.
12	8	Scientific theories** are reliable.
5	9	We can trust that scientists share their discoveries with us, even if they do not like what they find.
		Distrust Factor
Original scale no.	Adapted scale no.	
20	10	Today's scientists ignore the well-being of others to advance their research.
17	11	We cannot trust scientists since they have a biased viewpoint.
21	12	We cannot trust science as it is progressing too slowly.
6	13	Scientists do not value the opinions of others.
2	14	Scientists ignore other studies that do not support their own work.
19	15	We cannot trust that scientists take into account ideas that contradict their own.
1	16	I lose trust in scientists when they change their mind about a scientific idea.

Trust in Science and Scientists Inventory Turkish version:

Bilime ve Bilim İnsanlarına Güven Ölçeği

Ölçekte yıldızla işaretlenen kelimelerin anlamları aşağıdaki gibidir:

*** Etik:** Ahlak kurallarına uygun.

**** Teori:** Bir olayı gözlem ve deneyler yardımıyla açıklayan bilimsel görüşlerdir.

Güven Faktörü

Orijinal ölçek no	Uyarlanan ölçek no	
10	1	Bilim insanlarının, çalışmalarında dürüst olduklarına güvenmeliyiz.
9	2	Bilim insanlarının çalışmalarına güvenmeliyiz.
11	3	Bilim insanlarının, çalışmalarında etik* davrandığına güvenmeliyiz.
16	4	Bilim insanlarının, teknolojiyle ilgili önemli problemlerimize çözüm bulabileceğine güvenirim.
15	5	Doğal yaşama dair açıklamalara ulaşmak için bilime güvenebiliriz.
7	6	Bilim insanlarının çalışmalarıyla hayatı bizim için daha iyi yaptıklarına güvenirim.
14	7	Bilimi daha iyi anlayan insanlar, bilime daha çok güvenir.
12	8	Bilimsel teoriler** güvenilirdir.

5	9	Bilim insanlarının, buldukları hoşlarına gitmese bile keşiflerini bizimle paylaşabileceklerine güvenebiliriz.
		Güvensizlik Faktörü
Orijinal ölçek no	Uyarlanan ölçek no	
20	10	Günümüz bilim insanları araştırmalarını ilerletmek için başkalarının iyiliğini görmezden gelirler.
17	11	Bilim insanlarına güvenemeyiz çünkü onlar önyargılı bakış açısına sahiptir.
21	12	Bilime güvenemeyiz çünkü bilim çok yavaş ilerliyor.
6	13	Bilim insanları başkalarının fikirlerine değer vermez.
2	14	Bilim insanları kendi çalışmalarını desteklemeyen diğer çalışmaları görmezden gelir.
19	15	Bilim insanlarının, kendi fikirlerine ters düşen düşünceleri dikkate aldıklarına güvenemeyiz.
1	16	Bilim insanları, bilimsel bir fikir hakkında görüşlerini değiştirdiklerinde onlara olan güvenim azalır.

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Research Article

The Impact of Reconstructing Historical Scientific Experiments with Secondary School Students on Their Academic Success and Word Association Levels

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Abstract – This study aims to investigate the impact of faithfully reconstructing the experiments in the history of science on the academic success and word association levels of secondary school students. It uses the one-group pretest-posttest weak experimental design, which is one of the mixed experimental designs. It was carried out for six weeks with 13 students in seventh grade in the physics group for the Development of Special Talents in a Science and Art Center located in Istanbul in the 2021-2022 academic year. During the practice, three experiments were performed by the students. Academic Success Test and Word Association Test, formed by the investigators, were applied to the students as a pretest and a posttest. A significant difference was found between the students' pretest and posttest academic success scores, which was in favor of the posttests. It was seen that new relationships were established between the concepts after the practice.

Key words: Academic success, scientific experiments, history of science, word association test.

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Introduction

Science is an attempt to discover facts and the laws binding them through observation and observational reasoning (Russell, 1935). Such laws may be defined as hypotheses with a capacity to explain phenomena, and science, as a method, seeks to verify them (Yıldırım, 2018). Throughout history, scientists have built experiments using their imagination to develop and test hypotheses and revised or negated them in light of the results of such experiments (Kauffman, 1989). Experiments are central to producing new hypotheses and information, particularly in natural sciences (Ho-Ttecke, 2000). However, although experiments are part of the historical schemes, they have also been performed to suggest new studies, reinterpret past or existing research and eliminate any deficiencies. For these purposes, millions of experiments have been conducted since the systematic scientific studies by the Greeks around 400 BC (Harre, 2014). According to Unat (2021), the history of science is the analysis of scientific development periods, contributions of scientists and communities to science, and scientific thought by means of the method of the discipline of history. Considering how experiments are connected to the past, present, and future, scientific experiments in history have improved the understanding of the history of science, allowing us to understand and appreciate the conditions and processes in which scientists have lived (Chang, 2011; Lacin Simsek, 2009).

By nature of science, scientific information is built upon knowledge and is not immutable. Since all scientific ideas are based on experimental and observational verification, all scientific information may change, in principle, as new evidence comes up (National Research Council [NRC], 1996). One of the most favorable means to test ideas in this dynamic course of science is experiment. The history of science, on the other hand, may be regarded as the repository of meaningful experiments which can be reconstructed in classes (Bachtold, 2021). Up to date, scientific experiments and observations have helped eradicate many unclarities and contributed to a number of technological advancements. For instance, one of the foremost academic success of Galileo is that he proved the theorem of “average velocity” and differentiated it from “instantaneous velocity” (Drake, 1978). Studies by Galileo on free-falling and his law of free-fall, in particular, played a key role in the invention of the Atwood machine (Yavuz, 2008). Moreover, Joule (1850) found the mechanical equivalent of heat with his paddle wheel experiment. This experiment became the forerunner of the steam engines used today.

Studying friction force nearly 500 years ago, Leonardo Da Vinci suggested a linear relationship between normal force and friction force. He concluded that as the normal force was doubled, the friction force was also doubled and that the latter was independent of surface area (Pitenis et al., 2014). Today, the link between surface area and friction force is still a question of debate, and studies about such a connection are ongoing (Weber et al., 2018).

To the best of our present knowledge, we know that distilled water boils at 100 0C at sea level and that its temperature remains stable during the boil. We convey this piece of information to our students as a fact and expect them to remember it. However, former studies show that if distilled water reaches “superheat” at sea level, its boiling point can rise to higher temperatures. It indicates that modern science can overlook past information. Chang (2011) emphasized the need to relearn overlooked scientific knowledge through complementary experiments. He referred to his study of reconstructing historical experiments as "complementary experiments" to bring back lost information and generate ideas about controversial issues. Contributions of complementary experiments to science teaching can be defined in four items which are “enriching the fact-based resources of science teaching, helping students understand the nature of science, inviting students to think critically and outside the box, and evoking their curiosity about science”.

The body of literature includes studies on the repetition of experiments conducted in the history of science (Becu-Robinault & Tiberghien, 1998; Ho-Ttecke, 2000; Cavicchi, 2008; Heering, 2009; Eggen et al., 2012; Kostur, 2017; Ioannis & Polatoglou; 2019; Guven et al., 2022). Among them is a case study by Ho-Ttecke (2000) in which the experiments of Faraday & Galvani were repeated in that using faithful reconstruction of past scientific experiments as a learning and teaching tool allows for intellectual and emotional experiences. This study proposed such reconstruction as a method for teaching the history of science. Furthermore, in a similar study with two students, Cavicchi (2008) suggested that this method offered a specific capacity to convey the science curriculum and made any experimental activity more thrilling and productive.

Ioannis & Polatoglou (2019) reconstructed the experiments of Galileo with secondary school students and proposed that they made sense of the nature of science and the evolution of scientific thought within the framework of the changeability of scientific knowledge. Heering (2009), on the other hand, examined the role and effects of this method in science teaching with the “Coulomb experiment”. His study results showed that the use of historical experiments could enrich the nature of science and epistemological beliefs for science education. However, the same study also suggested that repeating experiments, which are critical for the initial development of a scientific concept, through the concept of "electrostatic" can contribute to the development of students' conceptual understanding. As a result of his study conducted by repeating the first physics experiments in history with high school students and receiving their opinions, Cetiner (2016) stated that he received positive views on science/physics teaching conducted as mentioned. Based on his study, this method makes it possible to give students insight into the nature of science and scientific knowledge and teach them the basic concepts. In their study correlating success at all grades with key scientific experiments in the history of science, Guven et al. (2022) drew attention to the importance of integrating the experiments from the history of science into science education, suggesting conducting experimental studies including such experiments in the classroom environment.

All these studies are based on replication of experiments from the history of science. In their study on the Voltaic Battery, Eggen et al. (2012) emphasized that the reorganization of these experiments creates a much more exciting teaching environment than usual. The body of literature includes experiments repeated with this method, such as the Voltaic battery (Eggen et al., 2012), Coulomb's torsion balance (Heering, 2009), Archimedes' crown of the king (Cetiner, 2016), Faraday's rotation engine (Ho-Ttecke, 2000) and Galileo's inclined plane, free fall and inertia experiments (Ioannis & Polatoglou, 2019). Da Vincin's friction experiment deserves to be repeated 500 years after its time. These studies revealed different results from those of Da Vinci regarding the independence of friction force from the surface area (Pitenis et al., 2014; Weber et al., 2018). It was believed that the discussion arising from the differences between the results of the original experiment and those obtained by today’s reconstruction would be nurturing for students in terms of concepts and the nature of science. Ioannis & Polatoglou (2019) focused on the scientific method, the development of which Galileo contributed to, by re-applying Galileo’s experiments with their students. The study inquiring about students' knowledge and opinions about this experiment shows that high school students have fallacies related to the concepts and information involved (Temiz & Kızılcık, 2016). In this context, it is critical to teach the concepts and information about the experiment. Since the 1900s, Joule’s paddle wheel experiment has been used in the quantitative teaching of the energy concept at the secondary school level (Becu-Robinault & Tiberghien, 1998). The experiment setup was used for the high school students to learn the problems of measuring heat, and it was thought that the experiment should be included in the teaching process (Jindrova, 2018).

Some of these experiments in the literature can be applied at the secondary school level (Guven et al, 2022); however, there is a lack of conceptual knowledge about most of them (Harrison et al., 1999; Jindrova, 2018; Sukarmin et al., 2018; Tavukcuoglu, 2018). Cetiner (2016), Devons & Hartmann (1970) and Kostur (2017) reported the contribution of repeating experiments from the history of science to learning concepts, scientific facts, and subjects. The accessible body of literature offers no study on the effect of remaking such experiments on academic success.

There are studies showing that students misassociate certain concepts such as mass-weight and velocity-speed and that they have misconceptions about such pairs (Koray & Tatar, 2003; Balbag, 2018; Uyduran 2019).

Some studies suggest that the same applies to the heat-temperature concept pair and that this misconception exists at the high school or even university level (Harrison et al., 1999; Sukarmin et al., 2018; Aydogan & Gunes, 2003). In addition to the misconception, some studies also propose that words similar to each other are used interchangeably. Yurumezoglu et al. (2009) state that it is hard to understand energy-related concepts and that similar concepts can be replaced with the concept of energy. Complementary assessment tools can be used to determine this situation. For example, Tasdere et al. (2014) used Word Association Test (WAT), a complementary assessment and evaluation technique, to determine the cognitive structures of pre-service science teachers towards the nature of science in their study and according to the concept networks drawn, it was determined that the post-test concept network at the end of the course showed a more complex and interrelated structure than the pre-test concept network. Kostova & Radoynovska (2008) also used the word association test to reveal students' scientific conceptual structures regarding cells and biodiversity. In our study, through the word association test, the students' minds a wider knowledge domain and knowledge network was probed for the concepts.

Science and Arts Centers (BİLSEM) are institutions established by the Turkish Republic Ministry of National Education (Milli Egitim Bakanlığı [MEB]) to ensure that students with special talents from pre-schools, primary schools, secondary schools, and high schools become aware of their abilities and develop and use them to the maximum (MEB, 2020). According to Guney (2018), BİLSEM students are expected to transform their potential into performance in fundamental scientific fields by gaining skills in scientific thinking and studying. In this respect, there is a need for differentiated education programs. It is known that using inquiry-based and differentiated teaching in the activities prepared for BİLSEM students has positive effects and that the students are willing to perform different experiments (Ulger & Cepni, 2020). As such, it is believed that the experiments from the history of science should be conducted with BİLSEM students in terms of application and conceptual level.

The study focuses on experiments in the history of science, which include concepts described as misconceptions in the body of literature. In this study, misconceptions are expected between the concepts of "mass and weight" in the Friction Experiment; between the concepts of "speed and velocity", "instantaneous speed and average speed" in the Average Speed Experiment; between the concepts of "heat and temperature" in Joule's Pedal Wheel Experiment. It aims to review students' academic success and word association levels related to experiments that are repeated faithfully.

The research question was formed by considering the importance of reconstructing historical scientific experiments in science education, the scarcity of applications with different experiments in the literature, and the historical and conceptual importance of the selected experiments. As such, the research question is as follows: Does faithful reconstruction of the experiments in the history of science affect the academic success and word association levels of BİLSEM students?

Method

In this study, the Simultaneous Triangulation Design (Concurrent- Triangulation Design) of the Mixed Method (Creswell, 2009) was used. Mixed design is defined by Creswell (2009) as a research approach in which both quantitative and qualitative data are collected and integrated, and results are drawn from these integrated data to understand the research question. In this study one-group pretest-posttest weak experimental design and "word association test" were used simultaneously. The quantitative data of the study were obtained with the academic success test and the qualitative data were obtained with the word association test. Although quantitative data on certain concepts is obtained with existing surveys and scales, it can be said that a broader field of knowledge about the relevant concepts is examined in the minds of students through the word association test. Because students are expected to present the concepts presented through WAT in the numbers they want, without limiting the words and phrases that they evoke in their minds. In addition, WAT provides the opportunity to obtain qualitative data because it reveals the concepts, words, and the relationships between words and conceptual organization put forward by students through concept networks (Tasdere et al., 2014). In this context, a one-group pretest-posttest weak experimental model was used in the study (Buyukozturk et al., 2018). The students participating in the application were determined by convenience sampling method. In the convenience sampling method, data are collected from a sample that the researcher can easily reach, and this accessible sample minimizes the loss of money, time and labor (Buyukozturk et al., 2018).

Conduct of the Study

This study was carried out with 13 students in the seventh grade in the Physics group for the Development of Special Talents (ÖYG) in a Science and Art Center in Istanbul in the 2021-2022 academic year. The practice period lasted for five weeks. Among the noteworthy experiments that scientists performed in the past, three were selected relating to the concepts in science lessons suitable for the students' age group. They are the Friction Experiment, Average Velocity Experiment, and Joule's Paddle Wheel Experiment (Hutchings, 2016; Ford, 2003; Bachtold, 2021). For each experiment, an experiment sheet was prepared by the investigators. Students were given presentations about how the scientists conducted their experiments under particular conditions then, and experiment setups were formed remaining faithful to the original version.

The Academic Success Test, which was prepared by the investigators and consists of skill-based questions, was applied to the students as a pretest and posttest to see how the acquisition of certain concepts worked for them. The relevant science concepts emphasized in the experiments were identified, and the Word Association Test (WAT) including such concepts was presented to the students before and after the application to analyze any word association levels. One of the experiments used in the study is described below as an example.

Conduct of the Friction Experiment

Students were informed about Leonardo da Vinci's life, his work, the historical background of the friction experiment, and why he was interested in friction force and they were shown his drawings (Figure 1).

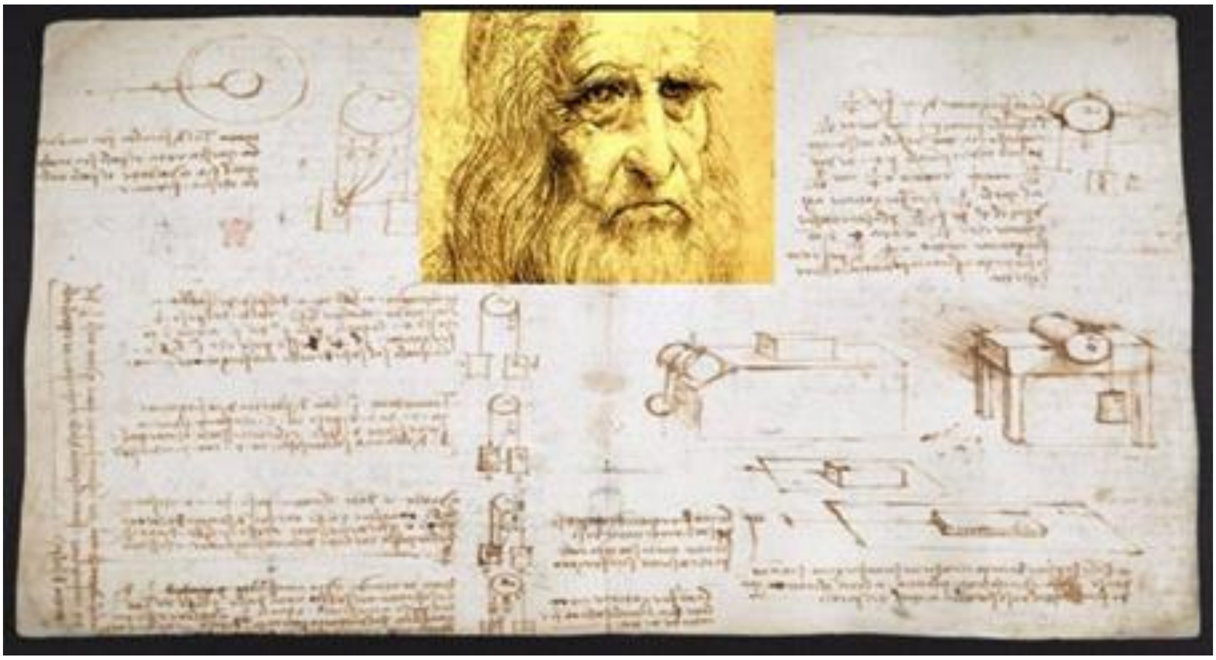

Figure 1 Drawings and portrait of Leonardo da Vinci (Hutchings, 2016)

Students were divided into groups of 3-4 people, given experiment sheets to follow during the experiment, and asked to perform the friction experiment in identical setups designed in line with the original experiment. Students were divided into groups of 3-4 students, given experiment sheets to follow during the experiment and asked to perform the friction experiment in identical setups prepared in accordance with the original experiment. In the friction experiment, it was tried to prove what the friction force changes depending on. For this reason, objects with equal masses, volumes and surface types were needed. These objects were obtained with 200 ml milk cartons of the same brand from supermarkets. In the friction experiment, the object moving horizontally and the object moving vertically were connected to each other with the help of a rope and a fixed pulley. The stage of connecting the rope to the milk carton was carried out with the help of a paper clip and tape. The movement and fall time of the suspended mass, which will fall under the effect of gravity, were observed. Students were expected to do the experiment following the setup in Figure 2 and record the results.

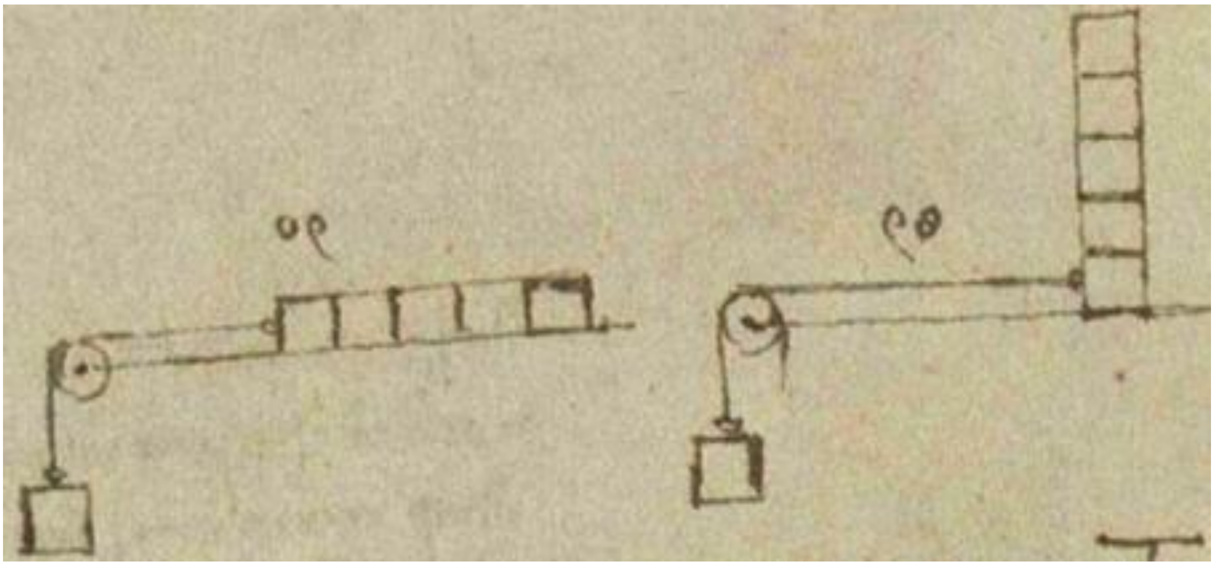

Figure 2 Drawings of Leonardo da Vinci, experimental setup (Pitenis et al., 2014)

In the next stages, the milk masses were increased and this increase was realized by adding another milk box to a milk box with the help of tape. The students were asked to add identical blocks next to the horizontal block as shown in Figure 3 and to observe the change in motion when the number of blocks on the horizontal increased. Then, the blocks were moved to the vertical position and the motion of the suspended mass was observed, the experiment was repeated with different positions of the blocks horizontally and vertically and the observations were recorded.

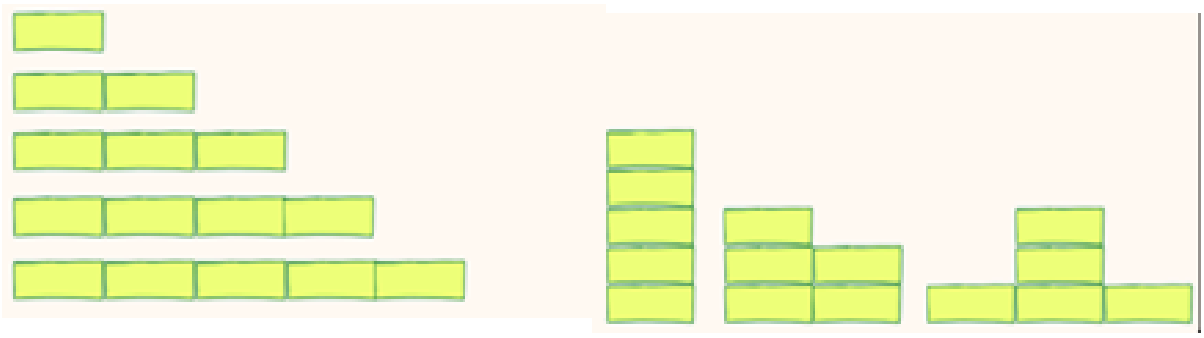

Figure 3 Different positions of the blocks connected to the bobbin

Finally, the experiment was conducted using a single block to observe the effect of the surface on the friction force. First, the suspended mass was observed connected to one block, then the bottom of the block was lubricated with soap, and it was observed again, comparing the motions. At the end of the experiment, the students shared their conclusions with their teachers and friends.

Data collection

In this study, Academic Success Test and Word Association Test prepared by the investigators were used to collect data.

Academic Success Test

Academic Success Test, which is prepared by investigators based on PISA questions and skill-based questions, to measure what students know and what they learn from each experiment and consists of 3 different groups of questions including comprehensive sub-questions for each experiment, was evaluated over the answer key formed in consideration of the "PISA question types and evaluation criteria" defined by Alkan (2013). The academic success test consisted of two open-ended two-stage tests: 1 fill-in-the-blank test from Davincin's friction force experiment, 1 open-ended test each from Galileon's average speed experiment and Joule's pedal wheel experiment A total of three questions were formed in the academic success test, one question for each experiment. Since the number of questions in the academic success test was small, these questions consisted of Pisa-style questions and were supported by open-ended questions, expert opinion was used to determine content validity.

Word Association Test (WAT)

The vocabulary association test, which is one of the alternative assessment and evaluation tools, is a technique that affects vocabulary learning and recall and gives important clues about how students construct knowledge (Istifci, 2010). In this study, the connections that students established between concepts through experiments and whether the connections established were correct or sufficient were examined. For the Word Association Test used in this study, concepts were defined for each experiment, and students were asked to write down 6 words and a sentence related to each concept within 60 seconds. The concepts of "friction force", "normal force", "weight" and "mass" for Davincin's friction force experiment; "velocity", "average velocity", "acceleration" and "gravity" for Galileo's average velocity experiment; "heat", "temperature", "work", "potential energy", "kinetic energy", and "mechanical energy" for Joule's pedal wheel experiment were used. The concepts used and the general structure of the test were formed in line with the expert opinion.

Data Analysis

Academic Success Test

The test was applied to 13 students as a pretest, and it was evaluated by 4 investigators, who were science teachers and doctoral students. The consistency between the raters was checked and found 90.3%. In order for the inter-rater evaluation results to be considered reliable, the percentage of agreement must be above 75% (Sencan, 2005). The pretest and posttest Academic Success Test data of 13 students, who participated in both tests, were transferred to the SPSS 23.0 program, and statistical analyzes were made.

According to Can (2018), it is unlikely that the data display normal distribution since the sample size is less than 30, and non-parametric tests are used for groups without such distribution. If the group is non-parametric, Wilcoxon Signed Rank Test is used to compare the means of two measurements from a group. In this case, since the number of participants was less than 30 ($n<30$) and the pre and posttest scores of a group were to be compared, the Wilcoxon Signed Rank Test, one of the non-parametric tests, was used in the analysis of the data for the Academic Success Test.

Word Association Test (WAT)

The cutoff point technique was used in the evaluation of the word association test. In this context, 3-5 numbers below the maximum number of answers for the key concept are used as the cutoff point. Then, the answers above this frequency are placed in the first part of the map. In the next stage, the cutoff point is decreased, and new emerging concepts are added to the map. The same procedure is continued until all key concepts are revealed (Kırtak, 2010).

The students' answers were reviewed, and the most common concept cutoff point was identified as 3. Based on these frequency values, cut-off points were set, and concept maps were created.

Results

Results for the Academic Success Test

The data for the Academic Success Test were analyzed with the Wilcoxon Signed Rank Test, one of the non-parametric tests.

Table 1 Academic Success Test - Wilcoxon Signed Rank Test Results

Score	Rank	N	Rank Average	Rank Total	Z	p
Posttest Pretest	Negative Rank	2	3.00	6.00	-2.620	0.009
	Positive Rank	10	7.20	72.00		
	Equivalent Rank	1				

Table 1 shows that there is a significant difference between the posttest-pretest Academic Success Test scores and this significant difference is in favor of the posttests ($p<.05$).

Results for the Word Association Test (WAT)

Students in the study read the concepts in the WAT and noted the words they associated with them. These words were listed and put in an order depending on the frequency of repetition. Concept maps were created by using the words written down by students about each concept before and after the application, and the relationship between the WAT pretest and posttest data was analyzed. The numbers above the arrows in the concept maps signify the frequency of words associated with the concepts. The data for WAT applied before and after the experiment and the concept maps based on these data are as follows.

Results of the Friction Experiment

Below are the results of the concept maps built on the results of the WAT applied as a pretest. The main concepts of the experiment are "friction force", "normal force", "weight" and "mass". The concept map of the pretest word association tests in the Friction Experiment is given in Figure 4.

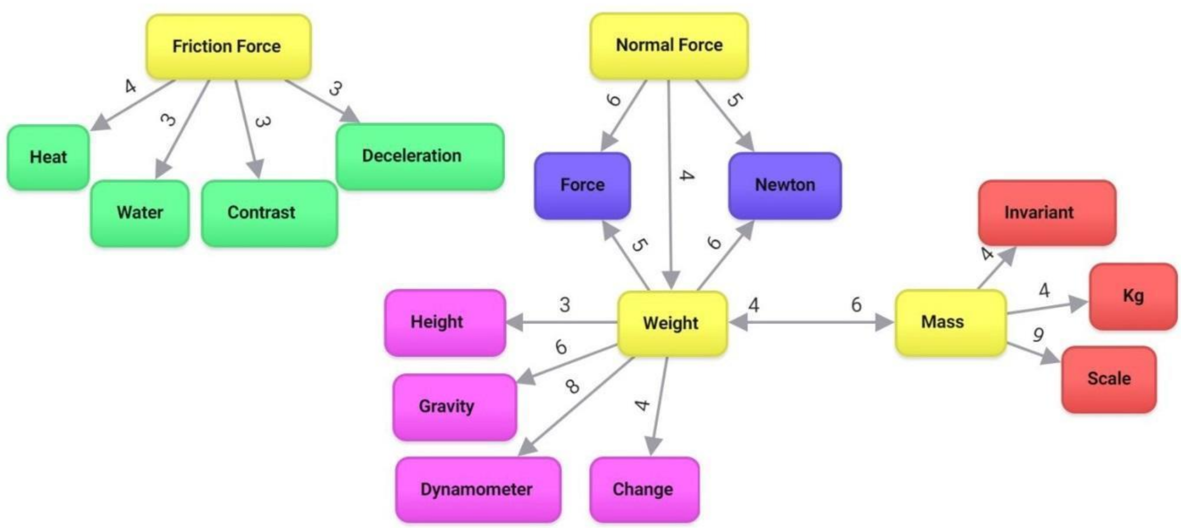

Figure 4 Pretest Concept Map for Friction Force Experiment

Below are the results of the concept maps built on the results of the WAT applied as a posttest. The main concepts of the experiment are "friction force", "normal force", "weight" and "mass". The concept map of the posttest word association tests in the Friction Experiment is given in Figure 5.

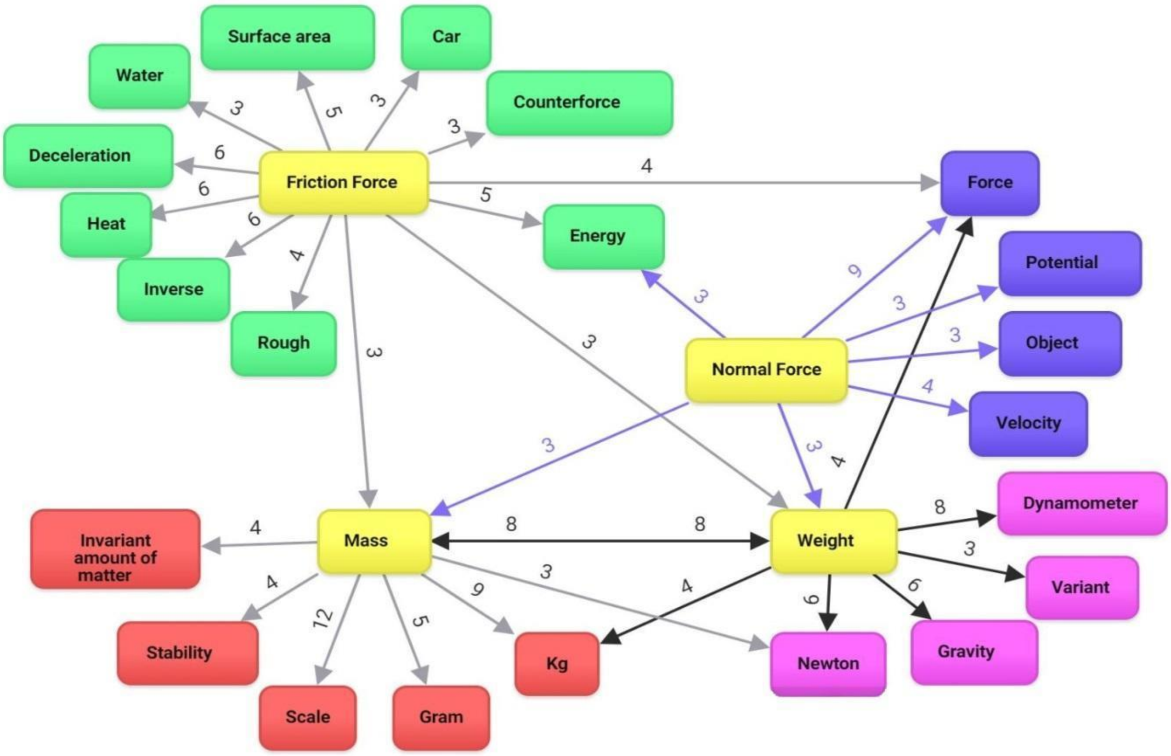

Figure 5 Posttest Concept Map for Friction Force Experiment

In the pretest, heat (f=4), water (f=3), contrast (3), and velocity reduction (f=3) were specified for friction force; force (f=6) and newton (f=5) for normal force; dynamometer (f=8), mass (f=6), gravity (f=6), change (f=4), and height (f=3) for weight; and scale (f=9), kg (f=4), invariant (f=4), and weight (f=4) for mass. On the other hand, in the posttest, deceleration (f=6), inverse (f=6), heat (f=6), energy (f=5), surface area (f=5), rough (f=4), and counterforce (f=3) were indicated for friction force; force (f=9), and velocity (f=4) for normal force; mass (f=8), dynamometer (f=8), and newton (f=6) for weight; and scale (f=12), kg (f=9), and weight (f=8) for mass.

- Pretest data show that the students were not able to associate the friction force with weight and mass, other main concepts; however, they could establish this relationship in the posttest.

- While the frequency of the associated words for each concept increased, new words were added. These new associations included "friction force - rough", "friction force - surface area", "friction force - counterforce", "normal force - velocity", and "friction force - energy".

Examples of sentences built by students about friction force and normal force according to the pretest WAT results are given below.

> *"The car was rubbing against the road", "Friction force does not always run counter to movement",* and *"Friction force is the counter force acting on the object"*; and, for normal force, *"It is a form of force", "Every object has a normal force"* and *"It does not slow down or speed up the object".*

Examples of sentences built by students about "friction force" and "normal force" according to the posttest WAT results are given below.

> *"Oil is used on the hinges to reduce friction", "It makes it more difficult to move" and "If it combines with kinetic energy, heat energy emerges".*

- The concepts of mass and weight were associated in both the pretest and the posttest.

Examples of sentences built by students about "weight" and "mass" according to the pretest WAT results are given below.

> *"It is the variant force of man", "Weight is a form of force" and "Weight may vary with planets"; and, for mass, "Mass is the invariant quantity of matter", "The mass of my car is 2000 kg" and "It does not vary depending on our position in the world".*

Examples of sentences built by students about weight and mass according to the posttest WAT results are given below.

> *"It is measured with a dynamometer", "The weight of matter is proportional to gravity" and "It is the gravitational force that varies with the location of the matter or object", and, for mass, "It is the quantity of matter that does not vary based on the location of the matter or object", "It is measured with an equal-arm scale" and "Its unit is kilogram."*

Results of the Average Velocity Experiment

Below are the results of the concept maps built on the results of the WAT applied as a pretest. The main concepts of the Average Velocity Experiment are "velocity", "average velocity", "acceleration" and "gravity". The concept map of the pretest word association tests in the Average Velocity Experiment is given in Figure 6.

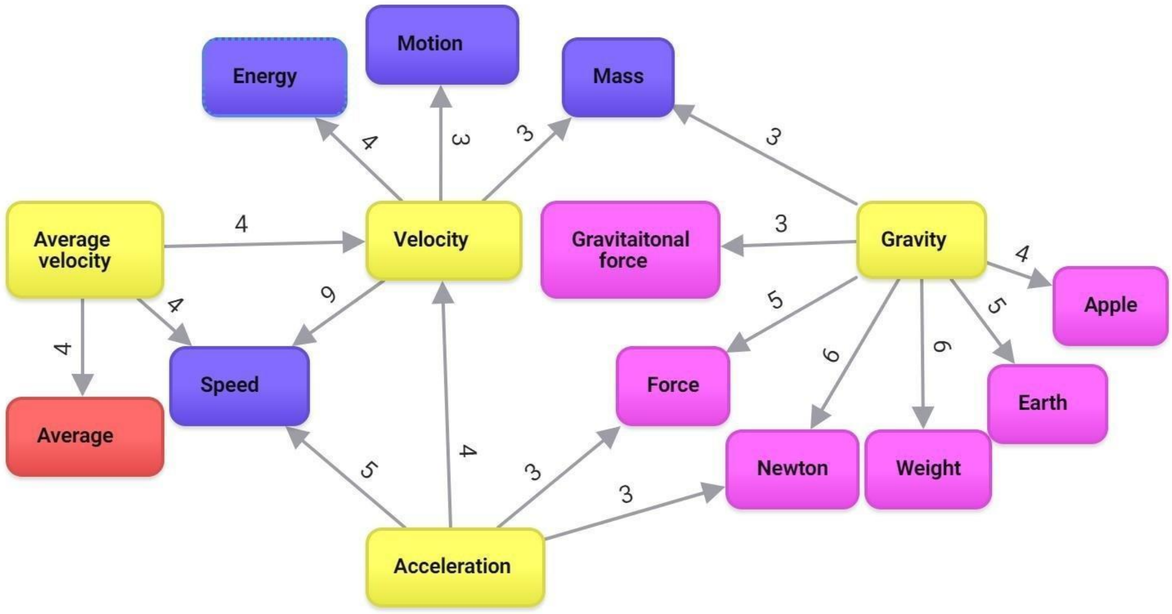

Figure 6 Pretest Concept Map for Average Velocity Experiment

Below are the results of the concept maps built on the results of the WAT applied as a posttest. The main concepts of the Average Velocity Experiment are "velocity", "average velocity", "acceleration" and "gravity". The concept map of the posttest word association tests in the Average Velocity Experiment is given in Figure 7.

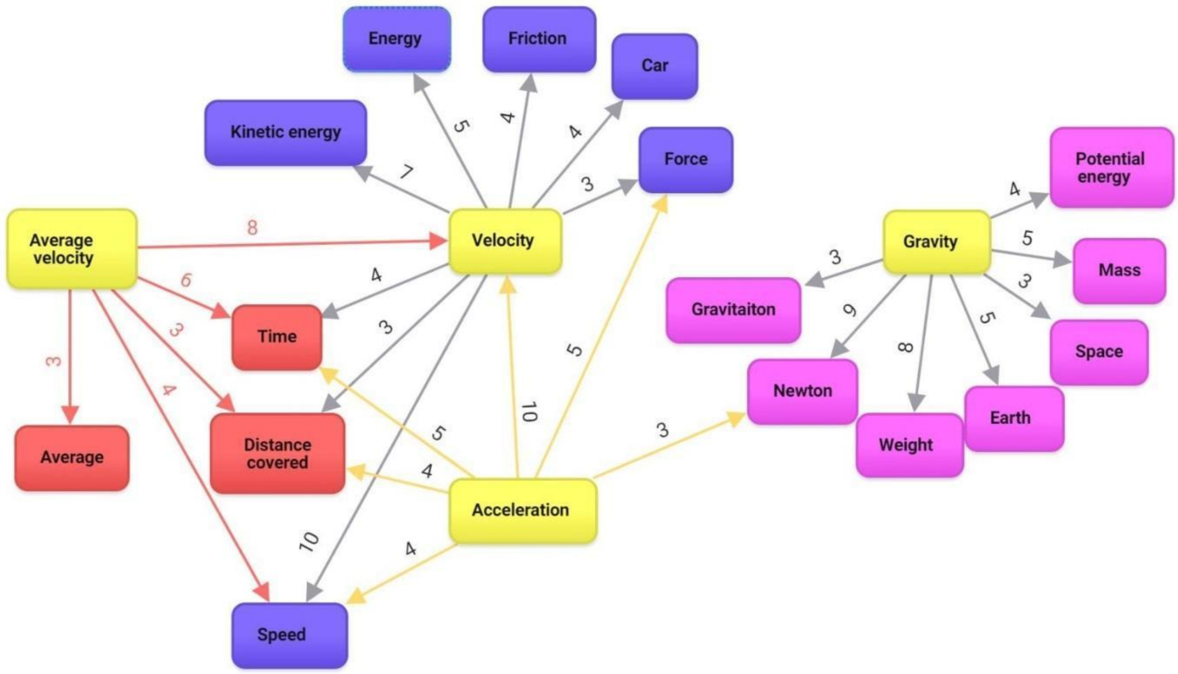

Figure 7 Posttest Concept Map for Average Velocity Experiment

In the pretest, speed (f=4), velocity (f=4), and average (f=4) were specified for average velocity; speed (f=10), energy (f=7), motion (f=3), and mass (f=3) for velocity; newton (f=6), weight (f=6), earth (f=5), and force (f=5) for gravity; and speed (f=5), kg (f=4), and velocity (f=4) for acceleration. On the other hand, in the posttest, velocity (f=8), time (f=6) and speed (f=4), and distance covered (f=3) were indicated for average velocity; speed (f=10), kinetic energy (f=7), energy (f=5), and friction (f=4) for velocity; newton (f=9), weight (f=8), and potential energy (f=4) for gravity; and velocity (f=10), force (f=5), and time (f=5) for acceleration.

WAT results show that the concept of kinetic energy was not mentioned in the pretests; however, in the posttests, half of the students associated the concepts of "speed" and "kinetic energy".

- The concepts of "distance covered" and "time", which were not included in the pretest, were associated with the concepts of "average velocity", "velocity" and "acceleration" in the posttest.

Examples of sentences built by students about average velocity and velocity according to the pretest WAT results are given below.

> *F*or average velocity, *"A car that exceeds the average velocity can crash", "It is dependent on the mass"* and *"Average velocity is a type of velocity";* for velocity, *"Vehicles crossing the speed limit are fined", "Velocity= distance x time"* and *"The speed of sound is less than the speed of light";* and for gravity, *"If there was no gravity we would fly",* and *"It is different everywhere".*

Examples of sentences built by students about average velocity and velocity according to the posttest WAT results are given below.

> For *average* velocity, *"It is the average of velocity", "If we add the velocities of two or more cars and divide it by the number of cars, we can find the average velocity"* and *"An object traveling on a straight road has an average velocity";* and for velocity *"The kinetic energy of an object depends on its velocity and mass".*

- Examples of new associations added to the posttest include the pairs of "gravity-potential energy", "velocity-kinetic energy", and "velocity-friction".

Examples of sentences built by students about gravity according to the pretest WAT results are given below.

> "*Gravity is towards the center of the Earth";* and for acceleration, *"It depends on velocity per unit of time", "The acceleration of the object A is 20"* and *"One of Newton's laws is the law of acceleration".*

Results of Joule's Paddle Wheel Experiment

Below are the results of the concept maps built on the results of the WAT applied as a pretest. The main concepts of Joule's Paddle Wheel Experiment are "heat", "temperature", "work", "potential energy", "kinetic energy", and "mechanical energy". The pretest concept map of Joule's Paddle Wheel Experiment is given in Figure 8.

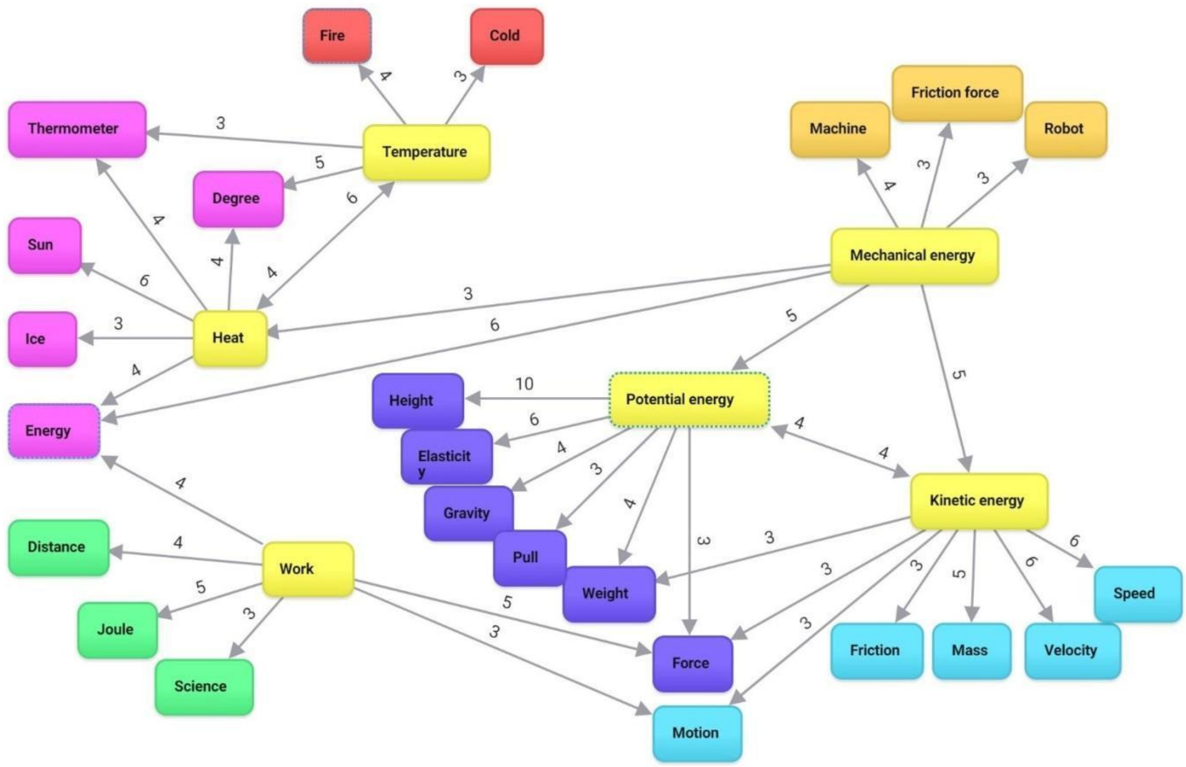

Figure 8 Pretest Concept Map of Joule's Paddle Wheel Experiment

Below are the results of the concept maps built on the results of the WAT applied as a posttest. The main concepts of Joule's Paddle Wheel Experiment are "heat", "temperature", "work", "potential energy", "kinetic energy", and "mechanical energy". The posttest concept map of Joule's Paddle Wheel Experiment is given in Figure 9.

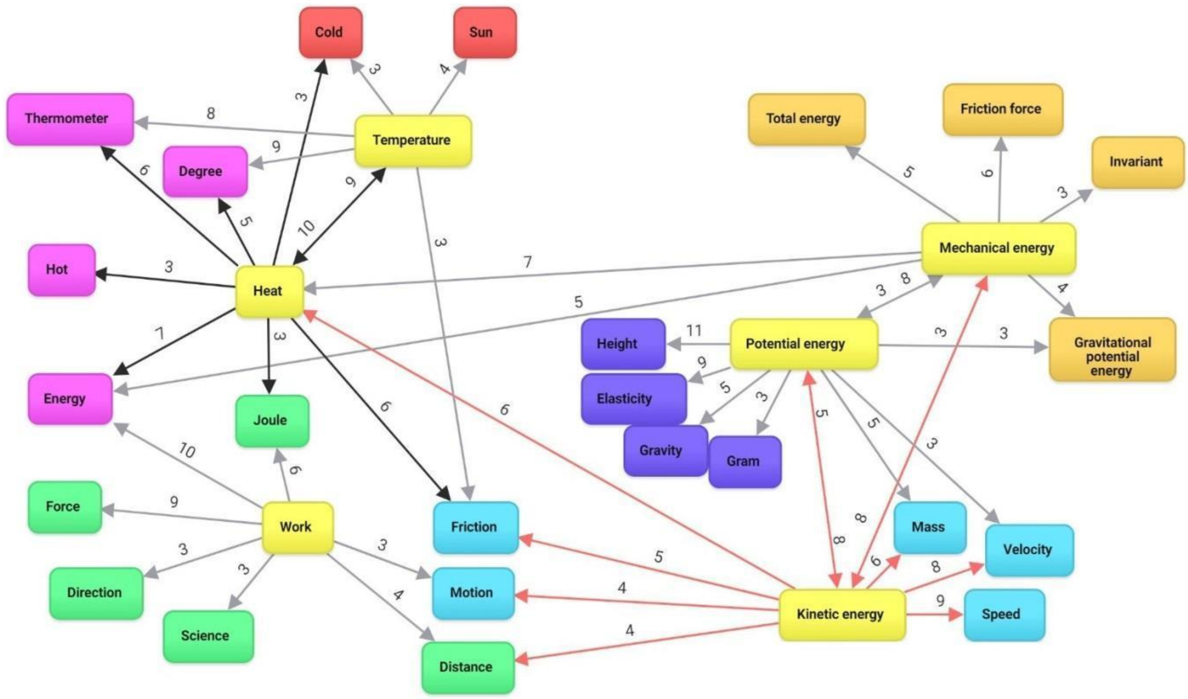

Figure 9 Posttest Concept Map of Joule's Paddle Wheel Experiment

In the pretest, temperature (f=6), sun (f=6), degree (f=4), energy (f=4), and thermometer (f=3) were specified for heat; degree (f=5), and heat (f=4) for temperature; joule (f=5), force (f=5), distance (f=4), energy (f=4), science (f=3), and motion (f=3) for work. On the other hand, height (f=10), elasticity (f=6), gravity (f=4), weight (f=4), force (f=3), and kinetic energy (f=4) were indicated for potential energy; speed (f=6), mass (f=5), potential energy (f=4), friction (f=3), motion (f=3), force (f=3), and weight (f=3) for kinetic energy; and energy (f=6), kinetic energy (f=5), potential energy (f=5), machine (f=4), friction force (f=3), robot (f=3), and heat (f=3) for mechanical energy.

In the posttest, temperature (f=9), thermometer (f=8), degree (f=5), hot (f=3), friction (f=5), and energy (f=1) were specified for heat; heat (f=10), degree (f=9), thermometer (f=8), and friction (f=3) for temperature; energy (f=5), force (f=9), joule (f=6), distance (f=4), motion (f=3), direction (f=3), and time (f=3) for work. On the other hand, height (f=11), elasticity (f=9), mechanical energy (f=8), gravity (f=5), gram (f=3), and gravitational potential energy (f=34) were indicated for potential energy; speed (f=9), velocity (f=8), mass (f=6), heat (f=6), motion (f=4), and distance (f=4) for kinetic energy; and potential energy (f=8), heat (f=7), friction force (f=6), gravitational potential energy (f=4), total energy (f=3), and invariant (f=3) for mechanical energy.

- According to the WAT results, links between the concepts increased and energy-related concepts were associated with others.

- While the concept of "friction" was not associated with "heat" and "temperature" in the pretests, relations were established between "friction and heat" and "friction and temperature" were established in the posttests.

- The students associated the concept of friction with heat and temperature in the posttest.

Examples of sentences built by students about heat and temperature according to the pretest WAT results are given below.

> For heat, *"the weather right now is 30 degrees Fahrenheit", "the heat the in room drops", "the Sun radiates heat and temperature"*; and for temperature, *"fire radiates temperature", "some materials can degrade if not kept at room temperature", "I measured the temperature with a thermometer".*

Examples of sentences built by students about heat and temperature according to the posttest WAT results are given below.

> For heat, "heat energy is generated as a result of friction", "heat and temperature are *different* concepts", "it is an energy"; and for temperature, "it is not an energy", "it is measure with thermometer", "as the temperature rises, some materials may be damaged".

- Examples of sentences built by students about work, potential energy, kinetic energy, and mechanical energy according to the pretest WAT results are given below.

> For *work, "in science, work and normal work are different things", "having no work is a pain in the neck", "the distance covered multiplied by the force applied equals to the work"*; for potential energy, *"it is the energy inside every living thing", "kinetic energy can be converted to potential energy", "it depends on height and mass"*; for kinetic energy, *"mechanical energy is calculated by adding kinetic energy and other energies together",* "*it is the energy of moving objects*", *"kinetic energy is also motion energy";* for mechanical energy, *"mechanical energy is the sum of kinetic and potential energy", "mechanical energy is the energy of a mechanism",* and *"machines can have mechanical energy".*

- Examples of sentences built by students about work, potential energy, kinetic energy, and mechanical energy according to the posttest WAT results are given below.

> For work, *"energy is the ability to do things" "the unit of work is Joule"* and *"if the object moves in the same direction as the force, it produces work"*; for potential energy, *"it is divided into two as gravitational potential and elastic potential" "it depends on mass and height"*; for kinetic energy *"it depends on the mass and speed of an object and is directly proportional to them", "when kinetic energy and friction force are combined, heat energy is produced", "the sum of kinetic energy and potential energy is mechanical energy"*; and for *mechanical* energy *"it is lost in case of friction force", "in case of no frictional force, it does not change",* and *"it is a form of energy".*

Conclusions and Suggestions

This study analyzes how the faithful reconstruction of experiments in the history of science affects academic success and word association levels. In conclusion, such reconstruction has a positive impact on academic success and word association levels. Comparing the pretest and posttest maps, which were created based on the results from all applications, it is seen that the concepts are produced similarly; however, the number of relationships established after the application increased, and learning took place by building new relationships.

Conclusion and Discussion for the Academic Success Test

The literature also shows that reconducting scientific studies from the history of science in science teaching contributes to learning many subjects, concepts, and scientific facts (Devons & Hartmann, 1970; Kostur, 2017). On the other hand, teachers think that using experiments in science teaching is a waste of time, especially for grades preparing for national exams (Gunes et al., 2013). According to Chang (2011), if sufficient motivation is ensured in learning science, extra learning can occur in addition to obtaining the information required by the curricula and exams. Students can gain motivation to learn science by performing experiments made in the history of science (Chang, 2011; Ho-Ttecke, 2000; Kortam et al., 2021).

Conclusion and Discussion for Word Association Levels

In the friction experiment, it is stated that the friction of the objects does not depend on the surface area, and the normal force increases with the weight of the object (Pitenis, et al., 2014). The most significant difference between the posttest concept map data and the pretest data is that students associate the concept of friction with surface area and weight. Students' misconceptions about associating friction force with surface area bring to mind the different results Weber et al. (2018) obtained from Da Vinci on the independence of friction force from the surface area.

In the friction experiment example, the "weight-kilogram" relationship in the posttest suggested that the students who established such a relationship had misconceptions about the units of weight and mass. Similarly, the presence of a relationship between “mass and Newton” supports the conclusion of Koray and Tatar (2003) that primary school students had many misconceptions regarding mass and weight. The results of the study show that students confuse not only the concepts of weight and mass but also the units of these concepts.

For the average velocity experiment, the associations of "velocity-kinetic energy" and "potential energy-gravity" are not included in the pretest but in the posttest. Uyduran (2019) stated that students associated kinetic energy with “velocity” and potential energy with “gravity” and indicated the variables on which kinetic and potential energy depend. The relevant study supports the results we obtained in our practice.

The posttest data indicate an association between the words "distance covered" and "time", and the concepts of "velocity", "average velocity" and "acceleration". Drake (1978) suggests that Galileo's objects falling with constant acceleration begin to fall slowly and that a gradual increase in their speed is proportional to the time spent. The data obtained from the study are in line with this statement. However, the frequency of associating the concepts of velocity and speed is high in the pretest and posttest, which suggests that the students confuse them (Balbag, 2018).

The fact that students associate the concepts of "thermometer" and "degree" with "heat", as well as "temperature" in the pretest and posttest, shows that they have a misconception about heat-temperature. The body of literature supports that misconceptions about heat and temperature are among the most common and continue even at the high school level (Harrison et al., 1999; Sukarmin et al., 2018). Aydoğan and Guneş (2003) found that such misconceptions were still present not only at the high school level but also at the university level. In his study, Harrison et al., (1999) emphasizes that these concepts are resistant to change and that conceptual progress should be supported by laboratory practices. According to the data obtained at the end of the application, it was seen that the heat-temperature misconception could not be eliminated in the experiment. This result, which supports the studies in the literature, shows that longer periods are required to eliminate the misconception about heat and temperature and to ensure word associations. On the other hand, the students did not establish the heat-joule relationship in the pretest but in the posttest, which may indicate that the students learned the unit of heat after the practice.

According to the WAT results, the words "machine" and "robot" were used in the pretest and "invariant" and "total energy" in the posttest for mechanical energy. It shows that the students were informed about mechanical energy at the end of the application. In addition, students associated all forms of energy with each other in the pretests and posttests. Yurumezoglu et al. (2009) suggest that since it is hard to perceive energy-related concepts, it leads to the interchangeable use of similar ones. However, it is also important for students to associate the concepts of temperature, heat, and friction after the experiment. Joule (1850) demonstrated the relationship between mechanical energy and heat in his experiment. It is believed that repeating this experiment enabled students to establish the relationship between temperature, heat, and friction.

Suggestions for Practitioners on Experiments

Investigator's Experience of the Friction Experiment

Different materials with the same mass and volume can be used instead of milk cartons, such as juice boxes or wooden blocks.

It is recommended to use a durable adhesive in the gluing process to attach the masses to each other.

Investigator's Experience of the Average Velocity

It is recommended that the length and width of the material used for the inclined plane should be chosen as large as possible in order to easily measure the time to complete the movement of the object released from the inclined plane. Because the time to complete the movement of an object released from a short inclined plane will be less, there will be difficulties in measuring the time. In a narrow inclined plane, the probability of deviations in the motion of the released object will increase and the object may not complete its motion by leaving the path of the inclined plane.

Investigator's Experience of the Joule's Paddle Wheel Experiment

It is recommended that the water-filled system should not be too large. Because the temperature increase that will occur in very large systems is much smaller and this temperature increase may be difficult to observe.

Compliance with Ethical Standards

Disclosure of potential conflicts of interest

No conflict of interest.

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Research involving Human Participants and/or Animals

The study involves human participants. Ethics committee permission was obtained from Marmara University, Institute of Educational Sciences Research Ethics Committee.

Tarihi Bilimsel Deneylerin Ortaokul Öğrencileri ile Yeniden Yapılmasının Öğrencilerin Akademik Başarılarına ve Kelime İlişkilendirme Düzeylerine Etkisi

Özet:

Bu çalışma, bilim tarihindeki deneylerin aslına sadık kalınarak yeniden yapılmasının ortaokul öğrencilerinin akademik başarılarına ve kelime ilişkilendirme düzeylerine etkisini araştırmayı amaçlamaktadır. Çalışmada karma deneysel desenlerden biri olan tek gruplu ön test-son test zayıf deneysel desen kullanılmıştır. Uygulama, 2021-2022 Eğitim-Öğretim yılında İstanbul'da bulunan bir Bilim Sanat Merkezi'nde Özel Yetenekleri Geliştirme Fizik grubunda yer alan yedinci sınıf seviyesindeki 13 öğrenciyle altı hafta boyunca gerçekleştirilmiştir. Uygulama sırasında üç deney öğrenciler tarafından yapılmıştır. Araştırmacılar tarafından oluşturulan Akademik Başarı Testi ve Kelime İlişkilendirme Testi öğrencilere ön test ve son test olarak uygulanmıştır. Öğrencilerin ön test ve son test akademik başarı puanları arasında son test lehine anlamlı bir fark bulunmuştur. Uygulama sonrasında kavramlar arasında yeni ilişkilerin kurulduğu görülmüştür.

Anahtar kelimeler: Akademik başarı, bilimsel deneyler, bilim tarihi, kelime ilişkilendirme testi.

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Research Article

Ecological Literacy Measurement Tool for Adults: Validity and Reliability Study

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Abstract – The aim of this study is to develop a valid and reliable measurement tool for obtaining information about the ecological literacy of adults. For this purpose, a 72-item and three-part measurement tool was created in accordance with information in the literature and presented to experts for their opinions. After finalizing the scale in accordance with the feedback received, the 25-item 5-point Likert-type Ecological Literacy Awareness Scale, the 17-item true/false-type Ecological Literacy Knowledge Test (1), and the 17-item multiple-choice Ecological Literacy Knowledge Test (2) were created. The exploratory factor analysis (EFA) group comprised 294 teacher candidates studying in the Ankara and Balıkesir provinces of Turkey. The confirmatory factor analysis (CFA) group comprised 376 teacher candidates. The 59-item draft measurement tool was administered to two study groups. These study groups were selected by convenience sampling method, a non-probability sampling method. The data of the first group were used for exploratory factor analysis and the data of the second group were used for confirmatory factor analysis. It was determined that the finalized 37-item and three-part Ecological Literacy Measurement Tool for Adults (ELMT) was valid and reliable in determining the awareness and knowledge of teacher candidates about ecological literacy.

Key words: ecological literacy, ecological awareness, measurement tool, teacher candidate, adult.

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Introduction

Ecological literacy entails understanding that the environment is the basis of prosperity (Boehnert, 2015). The literature on ecological literacy emphasizes the role of scientific knowledge and ecological thought in identifying cause-and-effect relationships related to the environment (Orr, 1992). The overall goal of ecological literacy is to create a frame of thought that recognizes relationships with the natural world, understands interactions, and supports the development of new possibilities for building interdependent sustainable ways of living. Ecological literacy thus prioritizes education to enable informed and engaged citizens to make decisions and take action on environmental issues (Lewinsohn et al., 2015).

While environmental literacy focuses on values and problem-solving, ecological literacy focuses on systems and transforming ecological knowledge into behaviors and attitudes (Coyle, 2005; Disinger & Roth, 1992; McBeth et al., 2008; Payne 2005, 2006; Roth, 1968; Roth, 1992). Eco-literacy involves general concepts such as sustainable living and Gaia (McBride et al., 2013). These concepts highlight the importance of environmental issues and the ability of individuals to use their knowledge to make choices in daily life.

The consensus among experts in this field is that “an ecologically literate person is one who understands the relevance and implications of ecological concepts and human impact on ecosystems” (Balgopal & Wallace, 2009). Vygotsky’s sociocultural theory of human learning, which states that the definitions of ecosystem concepts and those concepts themselves are developed through communication and natural observations, is of use for identifying ecologically literate individuals. According to this theory, social interaction has an important role in the development of cognition (Vygotsky, 2012). Since advanced cognitive development tools depend on the adoption of formal and non-formal education, cognitive development cannot be separated from its social context (Yılmaz, 2017). Thus, the lexicons created through background knowledge and context, different sociocultural backgrounds, and the different reflected worldviews need to be considered. To date, many scales for measuring ecological literacy have been developed (Casper et al., 2021; Changchen et al., 2022; Larijani, 2010; Morrone et al., 2001; Stables, 1998; Wilke, 1995a, 1995b).

When we look at the studies on environmental education, we come across studies that aim to define human-environment interactions regarding environmental knowledge, environmental beliefs, behaviors and ecological literacy (Louv, 2006; McBride et al., 2013).

"Environmental education" terms was searched and 86 scales found from Turkish Measurement Tools Directory between 1995 and 2020 have been indexed in the Turkish Measurement Tools Directory (*Türkiye Ölçme Araçları Dizini*: TOAD). These scales measure environmental awareness and sensitivity, environmental attitudes, environmental awareness, environmental behavior, environmental literacy, behaviors towards environmental problems, and the knowledge levels of certain age groups (Akbaş & Kırımlı, 2019; Aslan et al., 2008; Çabuk & Karacaoğlu, 2003; Okyay et al., 2021; Öcal & Önsüz, 2020; Ören et al., 2010; Özcan, 2022; Özdemir, 2023; Özer & Yıldırım, 2021; Timur & Yılmaz, 2013; Uzun & Sağlam, 2006; Yavuz et al., 2014; Yeşilyurt et al., 2013). The samples used in establishing and testing these scales have consisted of various grade levels of students receiving formal education. While there are tools that specifically measure the knowledge of adults regarding ecological literacy (Çabuk & Haktanır, 2017; Okur-Berberoğlu, 2020). The scale developed in the present study is unique in that it was prepared for adults and provides a multidimensional perspective for measuring knowledge and awareness of ecological literacy.

The items and dimensions of the scale were designed for the concept of ecological literacy as defined by Orr (1992) and Capra (1996). By this definition, ecological literacy involves understanding the natural processes that make life on earth possible and exhibiting knowledge, skills, attitudes, values, and understanding towards nature (Capra, 1996; Capra & Stone, 2010).

When the "Sustainable Development Goals" (https://www.kureselamaclar.org) adopted by 193 member countries of the United Nations in 2015 to be achieved by the end of 2030 are examined, it is seen that adults of all ages and professions have the responsibility of being ecologically literate in order to achieve these goals. In a study that systematically reviewed the research on education for sustainable development in early childhood, it was determined that the environmental dimension of sustainability was addressed rather than its socio-cultural and economic dimensions, and this was explained by the fact that environmental issues are more concrete for children (Güler-Yıldız et al., 2021).) It is known that childhood is a critical period in terms of learning to value the living and non-living beings that exist on earth, and that teachers have a very important role in supporting children to become responsible citizens towards their environment (Pamuk-Kahriman & Olgan, 2020; Scott & Sulsberger, 2019). For this reason, it is important to take the necessary precautions for teachers to become ecologically literate starting from the pre-service period. Taking these requirements into consideration, this study aimed to develop a scale to determine the ecological literacy levels of prospective teachers. It is thought that preparing training programs for teachers, taking into account the information to be obtained through this scale, will provide a scientific basis for the training to achieve its purpose.

This study was planned with the aim of developing a valid and reliable multidimensional measurement tool that will provide information about the ecological literacy of adults.

Method

In this section, the study groups, study design, demographic information, data collection tools, and data analysis are discussed.

Study Design

This study was planned with the aim of developing a valid and reliable multidimensional measurement tool that will provide information about the ecological literacy of adults. Accordingly, the study was conducted using a descriptive design. Descriptive research aims to develop tools for describing, comparing, classifying, analyzing, and interpreting the characteristics of individuals, groups, institutions, methods, or materials (Cohen et al., 2005).

Study Groups

This research included two study groups. The exploratory factor analysis (EFA) group comprised 294 teacher candidates studying in the Ankara and Balıkesir provinces of Turkey. The confirmatory factor analysis (CFA) group comprised 376 teacher candidates from Ankara and Balıkesir. The study groups were selected using the convenience sampling method as a non-probability sampling method (Büyüköztürk, 2008). Data on participants' demographic information, knowledge and opinions on environmental issues, and environmental awareness and knowledge of ecological literacy were obtained with forms developed by the researchers. All participants were enrolled in the study on a voluntary basis.

Table 1 Demographic information about EFA and CFA groups were given.

Table 1 Demographic Information of the Sample

	EFA Group*	CFA Group*
Age	19-25 years 92.5% (n=272)	18.1% (n=68) (First grade)
Grade	26-30 years 2.7% (n=8) 31-35 years 2.0% (n=6) 36-45 years 2.0% (n=6) 46 years and above 0.7% (n=2)	36.4% (n=137) (Second grade) 13.8% (n=52) (Third grade) 23.1% (n=87) (Fourth grade) 8.5% (n=32) (Other)
Department	5.6% (n=14) 6.1% (n=18) Biology Ed. 29.9% (n=88) Science Ed. 15.6% (n=46) Psyc. guidance and counseling Dept. 48.3% (n=142) Preschool Ed.	11.4% (n=43) Biology Ed. 1.3% (n=5) Science Ed. 71.8% (n=270) Preschool Ed. 0.5% (n=2) Classroom teaching Ed. 14.9% (n=56) Other departments
City	48.3% (n=142) Ankara 51.7% (n=152) Balıkesir	44.4% (n:167) Ankara 55.6%(n=209) Balıkesir
Gender	82.3% (n=242) Female 17.7% (n=52) Male	81.1% (n=305) Female 18.9% (n=71) Male
Total	294	376

EFA Group: Exploratory factor analysis group; CFA Group: Confirmatory factor analysis group

As seen in the Table 1, in the EFA group, 82.3% (n=242) of the participants were female and 17.7% (n=52) were male, while 92.5% (n=272) were aged 19-25 years, 2.7% (n=8) were aged 26-30 years, 2.0% (n=6) were aged 31-35 years, 2.0% (n=6) were aged 36-45 years, and 0.7% (n=2) were aged 46 years and above. In this group, 5.6% (n=14) of the teacher candidates studying at a university second time and those who were both employed and studying were aged 30 years and above. While 6.1% (n=18) of the participants were enrolled in undergraduate programs for teaching biology, 29.9% (n=88) were science teaching undergraduates, 15.6% (n=46) were psychological guidance and counseling undergraduates, and 48.3% (n=142) were preschool education undergraduates. Finally, 48.3% (n=142) of the participants lived in Ankara and 51.7% (n=152) lived in Balıkesir.

In the CFA group, 81.1% (n=305) of the participants were female and 18.9% (n=71) were male. The graduated participants were distributed as follows: 11.4% (n=43) were graduates of programs for teaching biology, 1.3% (n=5) were science teaching graduates, 71.8% (n=270) were preschool education graduates, 0.5% (n=2) were classroom teaching graduates, and 14.9% (n=56) had graduated from other departments. Among those who were currently studying, 18.1% (n=68) were in the first year, 36.4% (n=137) were in the second year, 13.8% (n=52) were in the third year, 23.1% (n=87) were in the fourth year, and 8.5% (n=32) were in other years of their programs. % 44.4(n=167) of the participants lived in Ankara and 55.6% (n=209) lived in Balıkesir.

Data Collection Tools

The data collection tools were developed in accordance with the scale development stages proposed by DeVellis (2017).

In the first stage, the theoretical models of and concepts related to ecological literacy, which the measurement tools developed in this study are intended to measure, were identified and explained.

In the second stage, a literature review was conducted. As a result, it was observed that various scientific studies on environmental literacy, environmental sensitivity, responsibility, environmentally friendly behaviors, and environmental awareness, knowledge, and attitudes have been conducted with children from different age groups and students studying in different undergraduate programs, mostly teaching programs. In addition, there are also studies reviewing educational programs and research conducted on the aforementioned topics. The item pool of this study was created primarily in accordance with the study by Morrone et al. (2001), as well as other studies conducted with students enrolled in different undergraduate teaching programs (Aksoy & Karatekin, 2011; Altınöz, 2010; Artun et al., 2013; Berberoğlu & Tosunoğlu, 1995; Çelebi Öncü & Ünlüer, 2015; Demircioğlu et al., 2015; Doğan, 2013; Erten, 2005; Genç & Genç, 2013; İbiş, 2009; Karakaya & Çobanoğlu, 2012; Karatekin & Aksoy, 2012; Kayalı, 2010; Kıyıcı et al., 2014; Özkubat & Demiriz, 2013; Özsevgeç et al., 2010; Teksöz et al., 2010; Timur, 2011; Tuncer et al., 2009; Tuncer et al., 2014). The dimensions of ecological literacy and the concepts involved in these dimensions were determined and an item pool including items for each dimension was created.

In the third stage, the format of the items was arranged to include 5-point Likert-type scale choices, true/false questions, and multiple-choice questions, with due diligence to ensure that the items appropriately measured the knowledge and behaviors of teacher candidates regarding ecology (Tezbaşaran, 2008).

In the fourth stage, an expert opinion form was prepared to obtain expert opinions on the dimensions of the tools and the concepts they addressed. A total of eight experts (one in measurement and evaluation, one in soil science, one in earth sciences, two in science education, and three in early childhood education) were asked to evaluate the 72 items in terms of their relationships with the four main topics of ecology: the basic principles of ecology, human-nature interactions, environmental values/environmental ethics, and sustainable living.

In the fifth stage, revisions were made in line with the opinions of the experts and three scale drafts with a total of 59 items were created. These were titled "Ecological Literacy Awareness Scale," "Ecological Literacy Knowledge Test (1)," and "Ecological Literacy Knowledge Test (2)." While Knowledge Test (1) consisted of true/false questions, Knowledge Test (2) consisted of multiple-choice questions. Thus, the validity and reliability of these tests were evaluated with different statistical methods. These knowledge tests were numbered sequentially for the same reason. The first part of the instrument included seven questions addressing the demographic information of the participants and their opinions on environmental issues.

In the sixth stage, the scale items were read to five adults. It was determined that three items were not comprehensible and they were revised. The draft scale with the revised items was then administered to 40 adults in writing. The evaluation revealed that the items in the scale were comprehensible. Finally, the scale was completed by volunteering teacher candidates.

Ecological Literacy Awareness Scale

In line with the experts' opinions, the final 25 items in the scale were formatted as a 5-point Likert-type scale and a draft scale form with instructions was created. Using the Likert-type system, respondents scored the extent to which they agreed with a given statement instead of choosing statements they agreed with. In other words, the respondent would respond to all items and indicate the degree of the response. The total score of the scale was calculated as the sum of these individuals scores. Thus, the awareness scale developed here was based on self-reporting (Tavşancıl, 2006: 198) and scale items were scored by respondents from 1 ("strongly disagree") to 5 ("strongly agree").

Sixteen of the scale items were positive statements and nine were negative statements. The items were listed randomly irrespective of the dimensions to which they belonged and whether they were positive or negative. Before implementation, five adults were asked to answer the draft scale verbally and the items in the scale were found to be comprehensible.

Ecological Literacy Knowledge Test (1)

The 17 items of this test were formatted as questions with true/false/don't know answers and a draft scale form with instructions was created. Scale items were scored as true (1) or false (0). Sixteen of the items consisted of true statements and one consisted of a false statement.

Ecological Literacy Knowledge Test (2)

The 17 items of this test were formatted as multiple-choice questions with four possible answers. A draft scale form with instructions was created.

Before implementation, five adults were asked to answer the draft scale verbally and the items in the scale were found to be comprehensible.

Statistical Analysis

EFA was used in the development process of the Ecological Literacy Awareness Scale and item and test statistics were calculated as part of the development process of the Ecological Literacy Knowledge Tests (1) and (2). The main purpose of EFA is to reduce or summarize a large number of variables that are thought to be related to each other into a smaller number of basic dimensions in order to facilitate understanding and interpreting the relationships between them. In other words, it is a method for dimension reduction and the elimination of dependency structures, similar to principal component analysis (Tatlıdil, 1996). Missing data, outliers, and normality assumptions were examined before the analysis was begun (Tabachnick & Fidell, 2001).

The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Barlett's test were also conducted before EFA. The KMO measure reflects the strength of the relationship between a dependent variable and a single independent variable when the effects of all other independent variables are constant. If this value is lower than 0.50, the data are not appropriate for factor analysis (Tavşancıl, 2006). Bartlett's test is used to test the null hypothesis, which posits that correlations in a correlation matrix are equal to zero, or that no relationship exists between variables. The results of Bartlett's test were found to be significant. Thus, it was concluded that there was a relationship between the variables and that this relationship was statistically significant (Kalaycı, 2009).

Eigenvalue calculations and scree plot curves were then used to determine how many dimensions the scale items would be grouped within (Çokluk et al., 2014). Items with factor loadings of less than 0.30 or more than 0.10 were removed from the scale (Büyüköztürk, 2008). Whether the variance explained by the remaining items in the scale was greater than 40% was examined in line with the calculated factor loadings (Çokluk et al., 2014). Finally, Cronbach's alpha reliability coefficient calculations were used to determine the reliability of the answers given to the scale items. The reliability threshold of the dimensions and the whole scale was found to be 0.60 (Kalaycı, 2009).

While developing the Ecological Literacy Knowledge Tests, discrimination and difficulty indices, which are among the approaches for item statistics, were calculated, and then the test statistics of the selected items were calculated. The item discrimination index measures the power of an item to distinguish respondents who have the characteristics intended to be measured from those who do not. The item difficulty index measures the percentage of respondents who answered an item correctly. As a result of these calculations, items with item discrimination values below 0.30 were removed (Özçelik, 2009). The content validity of the remaining items was examined and test statistics (descriptive statistics and KR-20 reliability) were calculated.

While developing the Ecological Literacy Awareness Scale, CFA of the data was performed for the second study group to examine whether the item factor distribution obtained in EFA was confirmed or not. Before CFA, the data were analyzed for accuracy, missing data, and outliers. As a result, some participants were identified as outliers according to their standardized z scores based on a range of +3 to -3, and they were excluded from the data pool (Çokluk et al., 2014). In addition, in order to examine the reliability of the data obtained from the second study group, Cronbach's alpha internal consistency coefficient and CR values were calculated for both the whole scale and its dimensions.

Results

In this section, findings related to the development of each measurement tool are reported.

Findings Related to the Development Process of the Ecological Literacy Awareness Scale

To examine the validity and reliability of the Ecological Literacy Awareness Scale, the answers of 294 adults who completed the scale were subjected to EFA. The KMO value was 0.790 and the result of Barlett's test was found to be significant ($p<0.05$). The data were thus determined to be appropriate for factor analysis (Tavşancıl, 2006). After the analysis, it was seen that there were four dimensions with eigenvalues greater than 1, but the difference between the eigenvalues of the last two dimensions was very small. Figure 1 shows that the items of the scale were grouped within two dimensions.

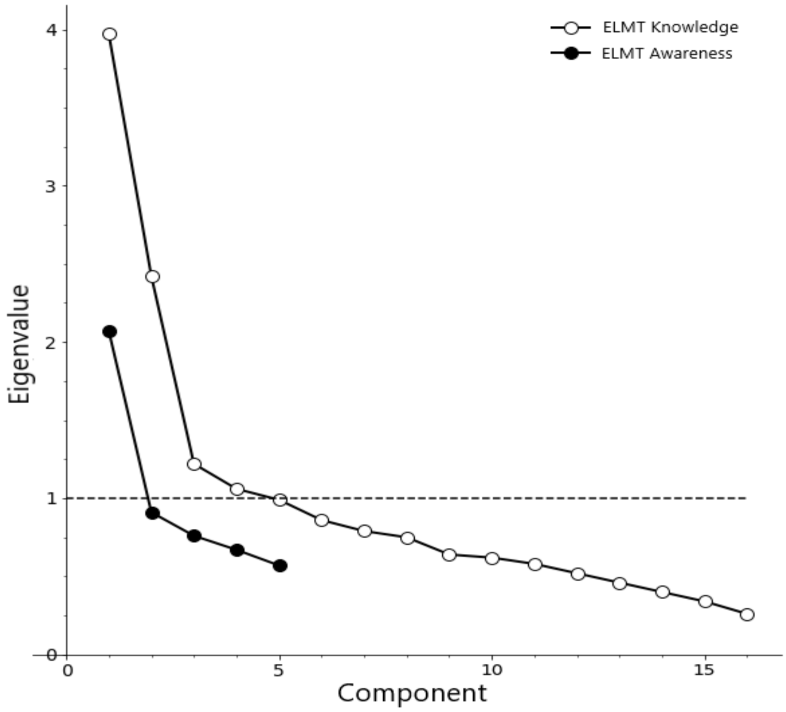

Figure 1 Factor Analysis Results Regarding Components and Eigenvalues of the Ecological Literacy Awareness Scale

In line with the information obtained, the analysis was repeated for two factors. Items with factor loadings below 0.30 and overlapping items (i.e., factor loadings between two factors being below 0.10) were removed from the scale. The analysis was repeated and orthogonal rotation was used to ensure more precise separation of item clusters. The factor loadings of the 16 items remaining in the scale after the analyses are shown in Table 2.

Table 2 Item Factor Loadings of the Ecological Literacy Awareness Scale

Item	Factor	
	1	2
MB9	0.801	0.065
MB10	0.752	0.197
MB8	0.641	0.070
MB12	0.614	0.038
MB6	0.588	-0.061
MB3	0.551	0.074
MB5	0.551	-0.100
MB20	0.543	0.326
MB21	0.488	0.302
MB15	0.430	0.184
MB2	0.412	-0.089
MB14	0.356	-0.186
MB23	-0.095	0.857
MB25	-0.107	0.805
MB24	0.254	0.652
MB22	0.051	0.548

Table 2 shows that the factor loadings of the 12 items in the first dimension of the scale varied between 0.356 and 0.801. The factor loadings of the 4 items in the second dimension of the scale varied between 0.548 and 0.857. It was determined that the items in the first dimension, named “Environmental Values and Environmental Ethics,” explained 25.315% of the variance, while the items in the second dimension, named “Sustainable Living,” explained 15.322% of the variance. The 16 items of the scale explained 40.637% of the total variance, which is a rate that can be considered valid for further analysis (Çokluk et al., 2014).

Cronbach’s alpha coefficient was used to determine the reliability of the answers given to the items of the Ecological Literacy Awareness Scale. The Cronbach alpha coefficient of the 12 items in the first dimension was 0.803 and that of the 4 items in the second dimension was 0.725. The reliability coefficient of the total 16 items of the scale was calculated as 0.773. This value suggested that the answers given by the teacher candidates to the scale items were reliable.

Some items from Ecological Literacy Awareness Scale:

8. I believe that the integrity of the ecosystem and the health of the natural environment determine the long-term health and well-being of people.

13. I believe that it is beneficial for the environment if the bag used for transportation is charged when purchasing any product.

15. I am ready to change my lifestyle to help protect the environment.

Findings Related to the Development Process of the Ecological Literacy Knowledge Test (1)

This 17-item test consists of true/false questions and it was prepared to measure the knowledge of adults about ecological literacy. Item discrimination and difficulty indices were calculated based on the answers of 294 adult respondents. The results are shown in Table 3.

Table 3 Discrimination and Difficulty Indices of the Items of The Ecological Literacy Knowledge Test (1)

Item	Item difficulty		Item discrimination	
	First analysis	Second analysis	First analysis	Second analysis
MC26	0.49	0.49	0.45	0.42
MC27*	0.91	---	0.10	---
MC28	0.73	0.73	0.49	0.56
MC29*	0.97	---	0.06	---
MC30	0.49	0.49	0.41	0.40
MC31*	0.98	---	0.04	---
MC32*	0.93	---	0.15	---
MC33	0.68	0.68	0.37	0.45
MC34	0.50	0.50	0.57	0.62
MC35*	0.94	---	0.07	---
MC36	0.41	0.41	0.49	0.55
MC37	0.51	0.51	0.47	0.51
MC38	0.52	0.52	0.42	0.42
MC39*	0.90	---	0.19	---
MC40*	0.91	---	0.14	---
MC41*	0.97	---	0.05	---
MC42	0.44	0.44	0.33	0.37

*Items removed from the test.

When Table 3 is examined, it is seen that the discriminatory powers of items 27, 29, 31, 32, 35, 39, 40, and 41 of the Ecological Literacy Knowledge Test (1) were below 0.30. These items were all answered correctly by 90% of respondents or more, which suggests low difficulty. Although these items were within the scope of the subject, it was determined that their discrimination was low as a result of their low difficulty for adults and these items were accordingly removed from the test.

Analyses were repeated for the remaining nine items in the Ecological Literacy Knowledge Test (1). Results showed that the difficulty indices of these items varied between 0.41 and 0.73. In other words, the test mostly comprised items with low to medium difficulty. The discrimination indices of the items ranged between 0.37 and 0.62. This indicates that the items in the Ecological Literacy Knowledge Test (1) had moderate to very good discrimination.

The test statistics of the items remaining in the test were calculated and the results are shown in Table 4.

Table 4 Test Statistics of the Ecological Literacy Knowledge Test (1)

Test statistics	Values
Number of participants	294
Minimum number of correctly answered questions	0
Maximum number of correctly answered questions	9
Mean difficulty of the items	0.530
Mean discrimination of the items	0.476
Reliability of the items (KR-20)	0.689

Table 4 shows that, of the 294 adult respondents, some could not answer any items of the Ecological Literacy Knowledge Test (1) correctly, while some answered all items correctly. The mean difficulty of the items in the test was calculated as 0.530. In other words, the test was found to have medium difficulty. Kline (2011) stated that achievement tests should be of medium difficulty. The mean discrimination of the items in the test was calculated as 0.476. Thus, it can be said that the test is a good discriminator. The reliability of the answers given to the items in the test was measured using the KR-20 coefficient. The KR-20 coefficient was calculated as 0.689, which showed that the internal consistency of the results was high.

Some items from Ecological Literacy Knowledge Test (1):

2. The increase in water temperature on the ocean surface affects the whole world.

5. Farmers grow corn one year, soy the next, and wheat the next year. This is called crop rotation. In this case, the need for pesticides is reduced.

7. The number of people the world can feed is limited.

Findings Related to the Development Process of the Ecological Literacy Knowledge Test (2)

The final aim of this study was to measure the knowledge of adults in terms of ecological literacy. Accordingly, item discrimination and difficulty indices were calculated for the 17 multiple-choice items based on the answers given by the participants. The results are shown in Table 5.

Table 5 Discrimination and Difficulty Indices of the Items of the Ecological Literacy Knowledge Test (2)

Item	Item difficulty		Item discrimination	
	First analysis	Second analysis	First analysis	Second analysis
ME50*	0.12	---	0.14	---
ME51*	0.89	---	0.09	---
ME52	0.75	0.75	0.32	0.33
ME53	0.26	0.26	0.30	0.34
ME54	0.60	0.60	0.32	0.31
ME55	0.63	0.63	0.30	0.34
ME56*	0.39	---	0.21	---
ME57	0.51	0.51	0.34	0.30
ME58	0.38	0.38	0.40	0.45
ME59*	0.87	---	0.19	---
ME60*	0.69	---	0.21	---
ME61	0.45	0.45	0.38	0.47
ME62	0.48	0.48	0.32	0.40
ME63	0.69	0.69	0.30	0.31
ME64	0.55	0.55	0.43	0.46
ME65	0.36	0.36	0.32	0.33
ME66	0.64	0.64	0.46	0.50

*Items removed from the test.

Table 5 shows that items 50, 51, 56, 59, and 60 of the Ecological Literacy Knowledge Test (2) had low discrimination (below 0.30). Accordingly, these items were removed from the test and the analyses were conducted again.

The item difficulty indices of the remaining 12 items of the Ecological Literacy Knowledge Test (2) were between 0.26 and 0.75. This suggests that the test mostly comprised items of low to medium difficulty. The discrimination indices of the items ranged between 0.31 and 0.50. This indicates that the items of the Ecological Literacy Knowledge Test (2) had moderate to very good discrimination.

The test statistics of the items remaining in the test were calculated and the results are shown in Table 6.

Table 6 Test Statistics of the Ecological Literacy Knowledge Test (2)

Test statistics	Values
Number of participants	294
Minimum number of correctly answered questions	0
Maximum number of correctly answered questions	12
Mean difficulty of the items	0.525
Mean discrimination of the items	0.373
Reliability of the items (KR-20)	0.695

Table 6 shows that, of the 294 adult respondents, some could not answer any items in the Ecological Literacy Knowledge Test (2) correctly, while some answered all items correctly. The mean difficulty of the items in the test was calculated as 0.525. This means that the test has medium difficulty. Kline (2011) stated that achievement tests should be of medium difficulty. The mean discrimination of the items in the test was calculated as 0.373. Therefore, the test was found to be a good discriminator. The KR-20 coefficient of this test was 0.695, which indicates that the internal consistency of the results was high.

Some items from Ecological Literacy Knowledge Test (2):

2. Which of the following is better than others in cleaning water in natural areas?

a. wetlands

b. lakes

c. rivers

d. I don't know

5. Which of the following is true about the total amount of water on Earth?

a. Increases

b. decreases

c. Constant

d. I don't know

Table 7 Parts and Numbers of Items in the Ecological Literacy Measurement Tool for Adults

Part	Format	Initial item count	Final item count
Awareness Scale	5-point Likert-type	25	16
Knowledge Test (1)	True/false	17	9
Knowledge Test (2)	Multiple-choice	17	12
Total		59	37

Table 7 shows the question formats used in the parts of the measurement tool and the distributions of initial items prepared according to expert opinions and final items remaining in the scale after revisions made based on validity and reliability analyses. As a result, the Awareness Scale had 16 final items, the Knowledge Test (1) had 9, and the Knowledge Test (2) had 12. Thus, the finalized Ecological Literacy Measurement Tool for Adults (ELMT) has a total of 37 items.

CFA Results

CFA was conducted to measure the construct validity of the Ecological Literacy Awareness Scale. The AMOS diagram of factor loadings and error variances obtained from CFA is given in Figure 2.

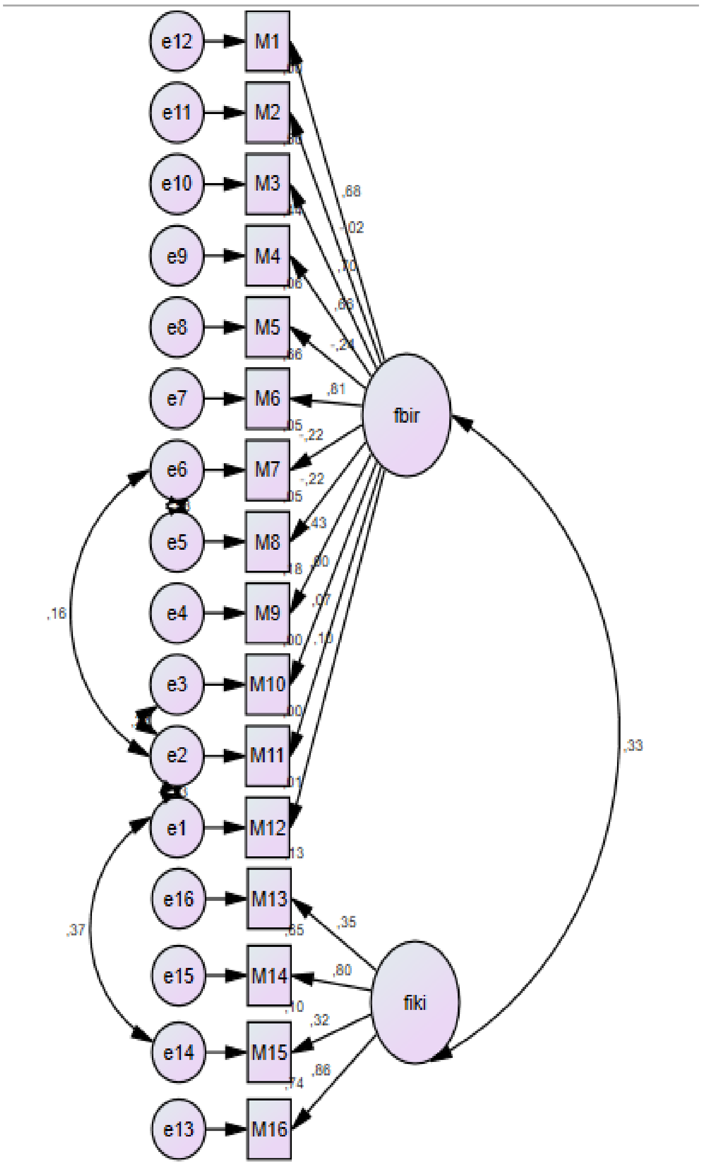

Figure 2 Ecological Literacy Awareness Scale AMOS Path Diagram

Various fit indices are used to examine the fit between covariance matrices. The fit index values and fit of the scale are accordingly presented in Table 8.

Table 8 Ecological Literacy Awareness Scale Confirmatory Factor Analysis Fit Indices

Fit Index	χ^2**/sd**	**GFI**	**IFI**	**RMSEA**	**RMR**	**TLI**	**CFI**
Value	(283,984/93) 3,054	0.907	0.878	0.074	0.081	0.839	0.875
Fit	Good Fit	Good Fit	Good fit	Good fit	Good fit	Good fit	Good fit

Table 8 shows that the χ2/sd (3.054) (Schermelleh-Engelet al., 2003), RMSEA (0.074) (Steiger, 2007), and RMR (0.081) (Brown, 2006 as cited in Çokluk et al., 2014) values of the scale reflect goodness of fit, satisfying the relevant thresholds of <5.00, <0.08, and ≤0.08, respectively. A GFI value of ≥0.90 (Tabachnick & Fidell, 2001) and TLI, CFI, and IFI values of ≥0.80 also indicate good fit (Browne & Cudeck, 1992; Chinda et al., 2012; Garson, 2008).

Table 9 Cronbach's Alpha, AVE, and CR Results

Items	**Factor loadings**	**Cronbach's alpha**	**CR**
Ecological Literacy Awareness Scale		0.727	0.935
Environmental Values and Environmental Ethics		0.625	0.896
M1	0.412		
M2	0.551		
M3	0.551		
M4	0.588		
M5	0.641		
M6	0.801		
M7	0.752		
M8	0.614		
M9	0.356		
M10	0.430		
M11	0.543		
M12	0.488		
Sustainable Living		0.695	0.878
M13	0.857		
M14	0.805		
M15	0.652		
M16	0.548		

Table 9 shows that the CR values of the Ecological Literacy Awareness Scale are above 0.8, which indicates that the scale has appropriate divergent validity (Fornell & Larcker, 1981). The Cronbach alpha coefficients of the scale suggest that the scale is reliable (Özdamar, 2004).

Conclusion, Discussion, and Suggestions

In this study, the Ecological Literacy Measurement Tool for Adults (ELMT) was developed to measure the ecological literacy of adults. The study was conducted with two study groups. EFA was conducted with data obtained from the first group of 294 teacher candidates and CFA was conducted with data obtained from the second group of 376 teacher candidates. As a result of the analysis of the findings, the finalized ELMT was designed to consist of three parts, including the Awareness Scale, Knowledge Test (1), and Knowledge Test (2).

EFA was conducted to confirm the validity of the ELMT. The results of that analysis indicated that the tool had appropriate fit between its whole and its parts. In addition, CFA was performed to determine whether the items were valid. The results showed that the construct and content validity of the ELMT were both adequate. The expert team assembled to determine the content validity of the ELMT stated that the items in each part of the tool would be able to measure the ecological literacy levels of adults. Hence, it was concluded that the ELMT could measure the selected characteristic.

For reliability analysis, the Cronbach alpha reliability coefficient and internal consistency (KR-20) coefficient were used. It was determined that the values obtained as a result of the reliability analysis of the ELMT were sufficient in relation to the whole scale. In other words, the tool was internally consistent.

The item pool of the scale initially included 72 items related to the four main topics of ecology: basic principles of ecology, human–nature interactions, environmental values/environmental ethics, and sustainable living. The 37 items remaining after validity and reliability analysis also addressed these four main topics of ecology, with 14 items for the basic principles of ecology, 7 items for human–nature interactions, 8 items for environmental values/environmental ethics, and 8 items for sustainable living. The basic principles of ecology (Duailibi, 2006), human-nature interactions (Muntean & Gînju, 2017), environmental values/environmental ethics (Martin, 2008), and sustainable living (Jiménez, 2019) were similarly associated with ecological literacy in various previous studies. Moreover, the ELMT includes topics addressed in the scale developed by Pitman and Daniels (2016) and the scale developed by Okur-Berberoğlu (2020) on ecological knowledge, while also including a new part on ecological awareness. Thus, it can be said that the ELMT measures a wider range of issues than its counterparts. Nevertheless, the ELMT is limited to the four basic principles of ecology and the concepts they involve. Future studies could expand the dimensions of the scale and develop different instruments by adding items related to other topics of ecology to this measurement tool.

In conclusion, it can be said that the 37-item ELMT is a valid and reliable measurement tool for measuring the ecological literacy of adults. This tool provides insight about the ecological literacy of respondents when all three parts and all items of the tool are applied together. Thus, the three parts of the scale should be used together. The tool has a score range of 16 to 101, with higher scores indicating higher levels of ecological literacy.

The results of this study show that a scale applicable for all professional groups involved in production and consumption, and especially researchers interested in environmental education, local governments wishing to determine the ecological literacy level of society, and non-governmental organizations, teachers, lecturers, and agricultural workers, has been produced.

The lacking knowledge of individuals whose ecological knowledge and awareness levels are measured with this tool should be advanced through preservice or in-service training programs, which can support individuals in developing the right attitudes and behaviors. It is also thought that the ELMT can be used in future studies to measure the effect and permanence of training programs prepared for adults after determining their ecological literacy levels. This tool does not measure the dimensions of attitudes and behaviors. Further development of valid and reliable measurement tools that can measure attitudes and behaviors in addition to the dimensions measured by the ELMT would provide a more comprehensive perspective on ecological literacy.

Compliance with Ethical Standards

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Yetişkinler İçin Ekolojik Okuryazarlık Ölçme Aracı: Güvenirlik ve Geçerlik Çalışması

Özet:

Bu çalışma yetişkinlerin ekolojik okuryazarlık durumları hakkında bilgi edinilebilecek, geçerli ve güvenilir bir ölçme aracı geliştirmeyi amaçlamaktadır. Bu amaçla alan yazın taranarak oluşturulan 72 madde ve üç bölümlük ölçme aracı uzman görüşlerine sunulmuş alınan dönütler doğrultusunda yapılan düzenlemelerle 25 maddelik 5'li likert tipi Ekolojik Okuryazarlık Farkındalık Ölçeği; 17 maddelik doğru/yanlış tipi Ekolojik Okuryazarlık Bilgi Testi (1) ve 17 maddelik çoktan seçmeli Ekolojik Okuryazarlık Bilgi Testi (2) oluşmuştur. Bu araştırmaya iki çalışma grubu dahil edilmiştir. Açımlayıcı faktör analizi (EFA) grubu Ankara ve Balıkesir illerinde öğrenim gören 294 öğretmen adayından oluşmuştur. Doğrulayıcı faktör analizi (DFA) grubu 376 öğretmen adayından oluşmuştur. Toplam 59 maddelik taslak ölçme aracı iki çalışma grubuna uygulanmıştır. Çalışma grupları olasılığa dayalı olmayan örnekleme yöntemlerinden kolay örnekleme yöntemi ile belirlenmiştir. Çalışma gruplarından ilkinin verileri açımlayıcı faktör analizi hesaplarında, ikinci grubun verileri ise doğrulayıcı faktör analizi hesaplarında kullanılmıştır. Yapılan analizler sonucunda 37 madde ve 3 bölümden oluşan "Yetişkinler İçin Ekolojik Okuryazarlık Ölçme Aracı" nın öğretmen adaylarının ekolojik okuryazarlık konusundaki farkındalık ve bilgi durumlarını belirlemede geçerli ve güvenilir olduğu belirlenmiştir.

Anahtar kelimeler: ekolojik okuryazarlık, ekolojik farkındalık, öğretmen adayı, yetişkin.

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