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FROM THE EDITOR

Dear Colleagues,

The *Journal of Theoretical Educational Science* is happy to publish the last issue of 2024! In this issue, you will find eight research articles by 17 authors. We are glad that these articles represent the different disciplines of education.

We should also express our sincere thanks to the Editorial Board, reviewers, and authors for their invaluable contributions. We look forward to receiving submissions from different parts of the world for the following issues!

Kindest regards,

Fatih GÜNGÖR, PhD
Afyon Kocatepe University
Faculty of Education

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A Bibliometric Analysis of Ten Years on Positive Psychology in Foreign/Second Language Education (2012-2022)

Yabancı/İkinci Dil Eğitiminde Pozitif Psikoloji Üzerine On Yıllık Bibliyometrik Bir Analiz (2012-2022)

Naile CANLI* **Devrim HÖL****

Received: 15 December 2023 **Research Article** **Accepted:** 10 August 2024

ABSTRACT: This bibliometric study examines the research trends, productivity, publication, and citation patterns of positive psychology in the field of foreign/second language education by analyzing 137 documents retrieved from the Web of Science (WoS) database between 2012-2022. Data analysis was conducted using various scientometric software, including MS Excel and Biblioshiny. Results reveal that the first publication on this topic appeared in 2012, with a major increase observed in 2021-2022, with the highest number of publications (n = 41) in 2022. The highest number of citations (n = 528) were observed in 2018. China was found to be the most productive country (n = 106), while Japan had the highest citation impact (n = 63). The most cited document received 198 citations. The study also found that the most frequently used word was "emotion" and the trending topic was positive psychology. The most productive university affiliation was found to be Birkbeck University of London in the UK.

Keywords: Bibliometric analysis, biblioshiny, foreign language education, positive psychology, second language education.

ÖZ: Bu bibliyometrik çalışma, 2012-2022 yılları arasında Web of Science (WoS) veri tabanından alınan 137 belgeyi analiz ederek yabancı/ikinci dil eğitimi alanında pozitif psikolojinin araştırma eğilimlerini, üretkenliğini, yayın ve atıf modellerini incelemektedir. Veri analizi MS Excel ve Biblioshiny gibi çeşitli scientometrik yazılımlar kullanılarak gerçekleştirilmiştir. Sonuçlar, bu konudaki ilk yayının 2012 yılında ortaya çıktığını, 2021-2022 yıllarında büyük bir artış gözlendiğini ve en yüksek yayın sayısının (n = 41) 2022'de olduğunu ortaya koymaktadır. En yüksek atıf sayısı (n = 528) 2018 yılında gözlemlenmiştir. Çin'in bu alanda en üretken ülke olduğu (n = 106), Japonya'nın ise en yüksek atıf etkisine (n = 63) sahip olduğu görülmüştür. En çok atıf alan belge 198 atıf almıştır. Çalışmada ayrıca en sık kullanılan kelimenin "duygu" ve trend konunun ise pozitif psikoloji olduğu tespit edilmiştir. En verimli üniversite ise Birleşik Krallık'taki Birkbeck University of London olarak tespit edilmiştir.

Anahtar kelimeler: Bibliyometrik analiz, bibliyoshiny, ikinci dil eğitimi, pozitif psikoloji, yabancı dil eğitimi.

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Recently, there has been a positive renaissance in the field of language education, as researchers and practitioners shift their focus from negative emotions to a more holistic examination of both negative and positive factors involved in the process of second language (L2) teaching and learning. This shift, first introduced by MacIntyre and Gregersen in 2012, has been driven by a growing interest in the role of emotions in foreign language learning (FLL) and teaching. Following their pioneering work, a number of early studies were published in peripheral journals, marking the beginning of a new area of research in the field.

Historically, research in applied linguistics has been dominated by a cognitive perspective which focused on the mental processes involved in language learning and teaching but in recent years, scholars have begun to investigate the impact of emotional states on language acquisition beyond previously established concepts such as foreign language anxiety and motivation. The field of educational research has been preoccupied on studying negative emotions, such as anxiety (Marcos-Llinás & Garau, 2009) and burnout (Vaezi & Fallah, 2011), within the realm of instruction for a prolonged period. However, in recent years, researchers inspired by the positive psychology movement have shifted their focus to the study and encouragement of eudemonic well-being (Jin et al., 2021). It may be argued that the conditions were favorable for the development of positive psychology within the field of applied linguistics due to the momentum of studies on the impact of "affective" factors, such as attitudes, motivation, and foreign language anxiety, which held a strong emotional component with a tendency to focus on negative emotions (anxiety) (Wang et al., 2021). Educational psychologists and teacher trainers had previously stressed the significance of positive emotions in FL classes (Arnold, 1999; Arnold & Fonseca, 2007) and the correlation between emotions and FL learning had been acknowledged (Bown & White, 2010; Dewaele, 2005, 2015; MacIntyre et al., 2019; Puozzo Capron & Piccardo, 2013). Despite this attention to the emotional aspect of FL learning, research in this area had remained relatively obscured in a field dominated by cognitive perspectives (Sharwood, 2017) and no link had been made to positive psychology. However, around the turn of the millennium, researchers began to shift their attention towards the role of emotions in FLL and teaching. This shift was driven by the recognition that emotions play a crucial role in shaping learners' and teachers' experiences of language learning and teaching, and that these experiences can have a significant impact on linguistic progress.

Positive psychology, henceforth abbreviated as PP for the sake of brevity, was initially proposed by Seligman and Csikszentmihalyi (2000) which encourages a change in attention from only dealing with negative aspects of life to cultivating positive attributes (Gao et al., 2020; MacIntyre, 2021). Theoretically, PP is underpinned by the broaden-and-build theory of positive emotions, which suggests that positive emotions lead to exploration, undo negative emotions, promote resilience, build personal resources, and lead to greater well-being (Lopez, 2008; MacIntyre & Gregersen, 2012; Seligman, 2011). In contrast to the broaden-and-build theory, applied PP in L2 education emphasizes that negative and positive emotions cannot be easily segregated and, in many cases, complement each other (MacIntyre & Gregersen, 2012; Wang et al., 2021). Positive emotions, as opposed to negative emotions which limit mindset, can encourage inventiveness and originality, leading to the accumulation of physical, psychological, intellectual, and social resources (Fredrickson, 2004). Positive emotions

may enhance the enjoyment and personal value of learning and teaching L2, as well as help L2 teachers and learners be more resilient when confronted with challenges (Gregersen, 2013). The emergence of foreign language enjoyment (FLE), as well as the study of factors such as happiness, emotional intelligence, love, and pride, has contributed to this shift in focus. Since the introduction of PP in this field, an increasing body of empirical research utilizing different epistemological and methodological approaches has provided a more nuanced understanding of the impact positive and negative emotions have on language learning and teaching. Additionally, PP interventions have been put into practice in schools and institutions all over the world with the purpose of boosting language development by enhancing learners' and instructors' experiences of flow, hope, courage, well-being, optimism, creativity, happiness, grit, resilience, and laughter.

In this vein, MacIntyre (2016) has identified four major contributions of PP to L2 education: (1) the shift from negative to positive emotion, recognizing the importance of both types of emotions in educational outcomes (Li et al., 2020); (2) the introduction of the model of character strengths, comprising six core categories, which can promote flourishing for teachers and students (MacIntyre, 2021; Park et al., 2004); (3) Oxford's (2016) development of the PERMA model towards EMPATHICS, which comprises nine factors related to emotion and empathy, meaning and motivation, perseverance, agency and autonomy, time, hardiness and habits of mind, intelligences, character strengths and self-related variables (Mercer & Gregersen, 2020); (4) the concept of flow outlined by Csikszentmihalyi (1990), which offers potential for examining the influence of experience on language learning attainment and success, although it has not been explored much in SLA studies (Liu & Song, 2021). While there have been criticisms of PP and early adopters of PP in applied linguistics, it's important to note that using PP in L2 education has the potential to enhance language learning. By promoting positive emotions and reducing negative emotions, PP can lead to greater well-being for both teachers and students. Nonetheless, much like a snowdrop after winter, the introduction of PP principles has brought new life to the field, providing a fresh perspective on the role of emotions in language learning and teaching (Dewaele et al., 2019). The growth of this novel field has been spurred on by a rising number of SLA researchers and those looking to incorporate psychological principles in language classrooms. Thus, it is important to understand both its current and potential future state. Furthermore, it is noteworthy that no bibliometric studies have been conducted to analyze research trends in the application of PP in FL education. Bibliometrics provide current trends for researchers, educators, and institutions in any field by utilizing search keywords and related fields within a specified time frame (Höl, 2022). Therefore, this study aims to utilize bibliometric analysis to gain insight into research trends in the application of PP in FL education, as well as to aid future researchers in understanding these trends. In this vein, the current study was conducted using meta-data retrieved from the Web of Science database in aim to address the following research questions:

1. What are the publishing and citation patterns for research on PP in foreign and second language education?
2. Which countries, institutions, and researchers are the most productive in this field?

3. Which journals do researchers prefer to publish their studies on PP in foreign language education?
4. What are the most common keywords and trending topics in this field?

Method

In this study, a bibliometric analysis was conducted to investigate the use of positive PP in FL education. Bibliometric analysis involves quantitatively analyzing and measuring scholarly literature through bibliographic data and citation patterns to identify leading researchers and institutions, track the development of new fields, and identify under-studied or under-funded research areas (Tijjani et al., 2020).

A detailed analysis of bibliographic information was performed using Biblioshiny, which is a web-based software from the Bibliometrix package that has been specifically developed for the purpose of analyzing bibliographic data. This tool enables users to search for, retrieve, and study bibliographic information from databases along with providing visualization tools that can be used to make sense of the data and present it in a clear and meaningful way.

Database Selection

We began by gathering raw data, including citations and search terms, from the Web of Science (WoS) database, which is globally recognized and preferred by thousands of researchers (Höl, 2022). Although this database includes various document types such as journals, books, reviews, and conference proceedings, our study focused on published articles in which reviews and proceeding papers were included. The WoS database was chosen for several compelling reasons. Many databases offer social sciences citation indexing services, including internationally recognized ones like Scopus and Google Scholar. However, scholars have acknowledged that the WoS Core Collection possesses higher quality standards compared to Scopus (Gaviria-Marin et al., 2019), resulting in fewer inaccuracies in identifying authors and keyword differentiation, owing to the use of keywords plus, therefore making WoS the most widely accepted and utilized database for scientific publication analysis. Keywords plus, also known as automatically generated keywords, are terms pulled from the WoS database based on their frequency of appearance in a document's reference list in which prevents issues when comparing documents. Additionally, the WoS Core Collection-Citation database offers a unique feature of citation counts, which allows the relative importance of articles to be quantified through an objective measure of influence (Dzikowski, 2018). These features have made WoS the ideal database for data mining, and it has emerged as one of the most popular databases used by researchers in conducting bibliometric analysis (Gaviria-Marin et al., 2019; Waltman & van Eck, 2012; Yan & Zhiping, 2023). In this study, information such as titles, authors, keywords, and citations were extracted from WoS.

Search Query

To gather information about bibliographic data related to PP in foreign/second language education, we utilized the WoS website. We implemented a specific search strategy that involved utilizing keywords such as "positive psychology", "foreign language", and "second language" in the title, abstract, and keywords of the studies.

Initially, we received 159 records, but narrowed it down by applying filters such as document type (articles, reviews, and proceeding papers) and selecting WoS categories of education and educational research and language and linguistics, resulting in 137 records. We also did not limit the time span in this study. The Prisma diagram strategy, a method for improving the reporting of systematic reviews and meta-analyses, was employed in this study (Aria & Cuccurullo, 2017; Moher et al., 2009).

Date of Data Extraction

The meta-data were retrieved on January 16, 2023, at Pamukkale University's Faculty of Education in Turkey using WoS to search for publications. This search query yielded a total of 137 items, including articles, reviews, and proceeding papers.

Data Analysis

Bibliometric analysis methods were used to extract relevant data from publications. Firstly, relevant keywords were used to identify all publications in the WoS database related to PP in FL education. This ensured that all pertinent data was included. For ensuring validity and reliability, the researchers conducted independent analysis of the bibliometric data, finding no differences in their results. Additionally, a thorough manual screening was performed, examining the title, abstract, and research questions/hypotheses of each article to determine their relevance to the fields of Positive Psychology and foreign/second language education. Moreover, although no language filters were applied, all retrieved publications were in English. The publications were then exported as plain text and analyzed using the Biblioshiny tool (version 4.2), which was accessed through Rstudio and the bibliometrix package. The Biblioshiny web interface was launched by entering "library(bibliometrix)" and "biblioshiny()" into the command line. The raw files were imported into the Biblioshiny tool for analysis. Finally, the results were analyzed using Microsoft Excel (V.16.61) to generate statistics, numbers, graphics, and charts.

Limitations

While this study offers valuable insights into the research productivity in PP in foreign/second language education, it has several limitations. Firstly, this study is restricted to the WoS database, which may exclude relevant publications from other databases such as Scopus or Google Scholar. Broadening the scope of the study could offer a more comprehensive perspective. Furthermore, the focus of the study was limited to specific subcategories within WoS, excluding other research areas like business, health, and politics. No filters were applied based on geographic location, language, or publication year. Secondly, methodological biases may arise from the focus on publication and citation metrics, which can prioritize quantity over quality. The reliability of bibliometric tools is subject to inconsistencies in citation practices and indexing variations, which can affect data accuracy. Highly cited papers may gain citations for reasons other than scholarly impact, such as being review articles or addressing popular topics. Thus, relying solely on citation counts to gauge research impact can be misleading. To address these issues, future studies should integrate qualitative assessments and alternative metrics to provide a more balanced and comprehensive evaluation of research contributions.

Results and Discussion

General Information and Historical Background

The primary objective of the current study was to construct a comprehensive overview of the relevant studies on PP in the context FL education. Through a thorough analysis, it was determined that between the years 2012 and 2022, a total of 137 papers on this topic were published. Notably, the earliest publication on PP in the EFL context was a proceedings paper entitled "Social Media's Learning Outcomes within Writing Instruction in the EFL Classroom: Exploring, Implementing, and Analyzing Storify," which was presented at the International Conference on Education & Educational Psychology (ICEEPSY, 2012).

Table 1 presents the key data that was retrieved regarding the formats of the published documents. The table provides an overview of the different types of publications, such as conference proceedings, journal articles, and books, that have been produced in the field of PP in the context of FL education. This information is essential for understanding the distribution of research across different formats and the relative importance of each type of publication within the field. For instance, it allows researchers to discern whether certain types of publications, like journal articles versus conference proceedings, receive more attention or are deemed more influential within the academic community. This understanding aids in evaluating the scholarly impact and dissemination of research findings within the field.

Table 1

General Overview of Article Publications

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	2012:2022
Sources (Journals, Books, etc.)	42
Documents	137
Annual Growth Rate %	35.26
Document Average Age	3.36
Average citations per doc	17.94
References	1
DOCUMENT TYPES	
Article	99
Article; Book Chapter	20
Article; Early Access	5
Proceedings Paper	3
Review	10
DOCUMENT CONTENTS	
Keywords Plus (ID)	313

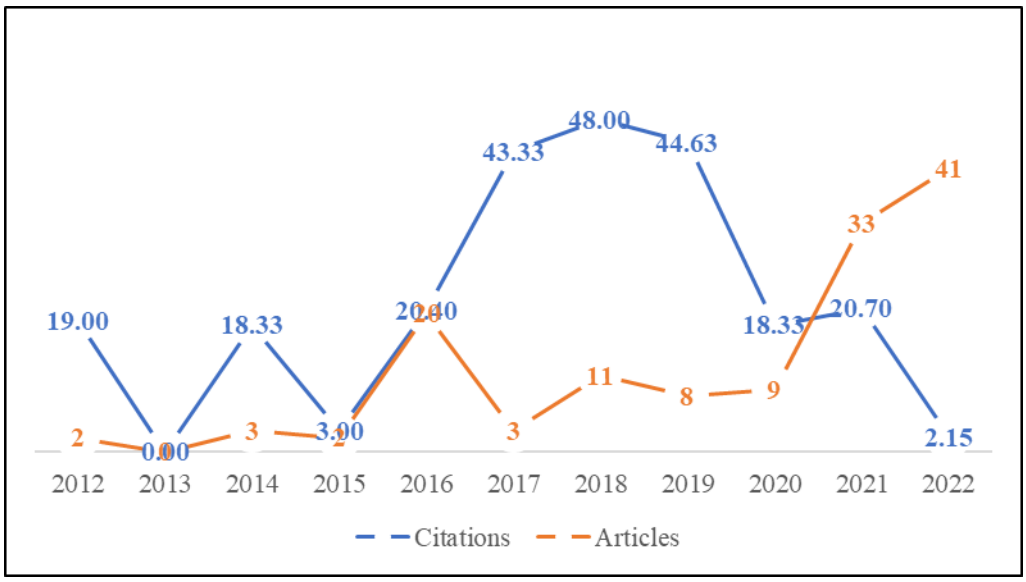
Author's Keywords (DE)	476
AUTHORS	
Authors	280
Authors of single-authored docs	37
AUTHORS COLLABORATION	
Single-authored docs	39
Co-Authors per Doc	2.39
International co-authorships %	27.01

Research Productivity

The current study aimed to investigate the trend of research related to PP in FL education. Specifically, the study sought to determine if there was an increase, stability, or decline in research in this area, as well as identifying any notable changes in trend and the years in which researchers were most prolific. In addition to analyzing the overall trend, the study included an analysis of the top ten countries and organizations based on their research productivity. This approach allowed for a deeper understanding of the global landscape of research in this area, highlighting the key contributors and their impact on the field. To begin, the annual research productivity in this field was analyzed using publications and citations data. Figure 1 illustrates the results of this analysis, which revealed that the first publication on this topic was published in 2012 and received a limited number of citations. However, a gradual increase in research productivity was observed, with a significant spike in 2021 and 2022, during which 54% of the publications were produced. Additionally, it was noted that the highest number of citations (n = 528) was received by 11 publications in 2018, with an average citation rate of 48% per year. The highest number of publications (n = 41) was reached in the year 2022. The annual growth rate of studies is approximately 35.26%. Overall, the analysis period of the recent decade demonstrates an upward trend in publications, with a particularly notable increase in popularity in 2016 and productivity beginning in 2020. In this vein, the year 2016 marked a significant milestone for PP in FL education, beginning a period of increased scholarly interest and productivity. Key events included the establishment of the International Association for the Psychology of Language Learning (PLL) following the second PLL conference at the University of Jyväskylä. This organizational step, coupled with initiatives like Multilingual Matters' new book series on 'Psychology of Language Learning and Teaching,' highlighted PP's growing influence in the field (Dewaele et al., 2019). Seminal edited volumes such as 'Positive Psychology in SLA' (MacIntyre et al., 2016) and 'Positive Psychology Perspectives on Foreign Language Learning and Teaching' (Gabryś-Barker & Gałajda, 2016) also underscored PP's practical applications. By 2017, established journals began integrating PP perspectives, solidifying its role in advancing theoretical frameworks and research methodologies in applied linguistics (Dewaele & Li, 2018; MacIntyre et al., 2019). These developments collectively marked 2016, referred to as the 'flowering' of PP in Applied Linguistics by Dewaele et al. (2019), as a pivotal year when PP gained significant attention and institutional support, reshaping discourse, and research agendas in language education.

Figure 1

Publications and Citation Trends from 2012 to 2022



As a comprehensive analysis, this study examined the citation analytics of publications in the field of PP in FL education to identify the most highly cited publications. The data revealed that the average number of citations per study was 17.94. This suggests that the literature within this area is active and well-established, with researchers frequently engaging with and building upon the ideas presented in prior publications. Furthermore, the most highly cited article was found to be Wan YL (2021) with 198 citations, followed by Dawaela JM (2016) with 191 citations. Table 2 presents a detailed breakdown of the citation structure for the top 10 most cited article publications regarding PP in FL education. These findings demonstrate the importance and impact of these studies within the field and provide insight into the most prestigious research in this area.

Table 2

The Citation Structure of Positive Psychology in FL Education Publications

Paper	Total Citations	DOI
Wang YL, 2021, FRONT PSYCHOL	198	10.3389/fpsyg.2021.731721
Dewaele JM, 2016, SECOND LANG ACQUIS	191	10.21832/9781783095360-010
Dewaele JM, 2019, FRONT PSYCHOL	179	10.3389/fpsyg.2019.02128
Dewaele JM, 2018, STUD SECOND LANG LE	127	10.14746/ssllt.2018.8.1.2
Li CC, 2018, SYSTEM	126	10.1016/j.system.2018.06.004
Xie F, 2021, FRONT PSYCHOL	121	10.3389/fpsyg.2021.708490
Macintyre PD, 2017, STUD SECOND LANG LE	106	10.14746/ssllt.2017.7.1.4
Li CC, 2020, APPL LINGUIST REV	75	10.1515/applirev-2018-0043
Piniel K, 2018, STUD SECOND LANG LE	63	10.14746/ssllt.2018.8.1.6
Shao KQ, 2019, SYSTEM	57	10.1016/j.system.2019.102121

Leading Countries and Institutions

Table 3 presents a comprehensive analysis of the top ten countries and organizations in terms of research productivity in the field of PP in FL education. This analysis is based on three key metrics: the number of publications (TP), total citations (TC), and the citation impact (CI).

China emerges as the foremost contributor with 106 publications, significantly outpacing other countries. Iran and the United Kingdom also had a significant number of publications, with 29 and 26 publications respectively. On the other hand, Austria had the lowest number of publications (TP = 5). When examining total citations, publications originating from China had the highest number (TC = 706). However, Japan stands out with the highest citation impact (CI = 63), suggesting that its relatively fewer publications (TP = 8) are of high quality and significance.

Furthermore, Belgium had the lowest citation impact (CI = 4.64), despite having a moderate number of publications (TP = 6) and citations (TC = 51) among the top ten countries. Overall, it is important to note China's dominance in publication metrics may skew the overall view of global research trends. Its leading position in both publication count and citation numbers could overshadow valuable contributions from other countries with smaller research outputs. While volume is essential, other countries with smaller outputs but higher citation impacts, like Japan, contribute high-quality, impactful research. This imbalance can skew the true scope of research impact, as it prioritizes volume over quality and innovation. To address this bias, it is crucial to use a range of metrics that assess research quality and relevance, ensuring a fair representation of all contributions in the field.

Table 3

Leading Countries and Institutions

Top 10 Countries					Top 10 Organizations			
Rank	Country	TP	TC	CI	Rank	Organization	TP	TC
1	China	106	706	11.97	1	Birkbeck Univ London	7	584
2	Iran	29	449	34.54	2	Univ London	6	908
3	UK	26	399	57	3	Cape Breton Univ	6	193
4	USA	25	336	30.55	4	Ferdowsi Univ Mashhad	5	71
5	Poland	14	153	30.6	5	Henan Univ	5	377
6	Canada	10	123	24.6	6	Huazhong Univ Sci and Technol	5	216
7	Japan	8	63	63	7	Univ Macau	5	35
8	Australia	6	51	25.5	8	Xiamen Univ	5	251
9	Belgium	6	51	4.64	9	Michigan State Univ	4	25
10	Austria	5	41	13.67	10	South China Normal Univ	4	121

Regarding the research productivity of the top ten organizations in the field, the Birkbeck University of London stands out as the leader, with 7 publications and 584 citations. The University of London and the Cape Breton University also demonstrate a

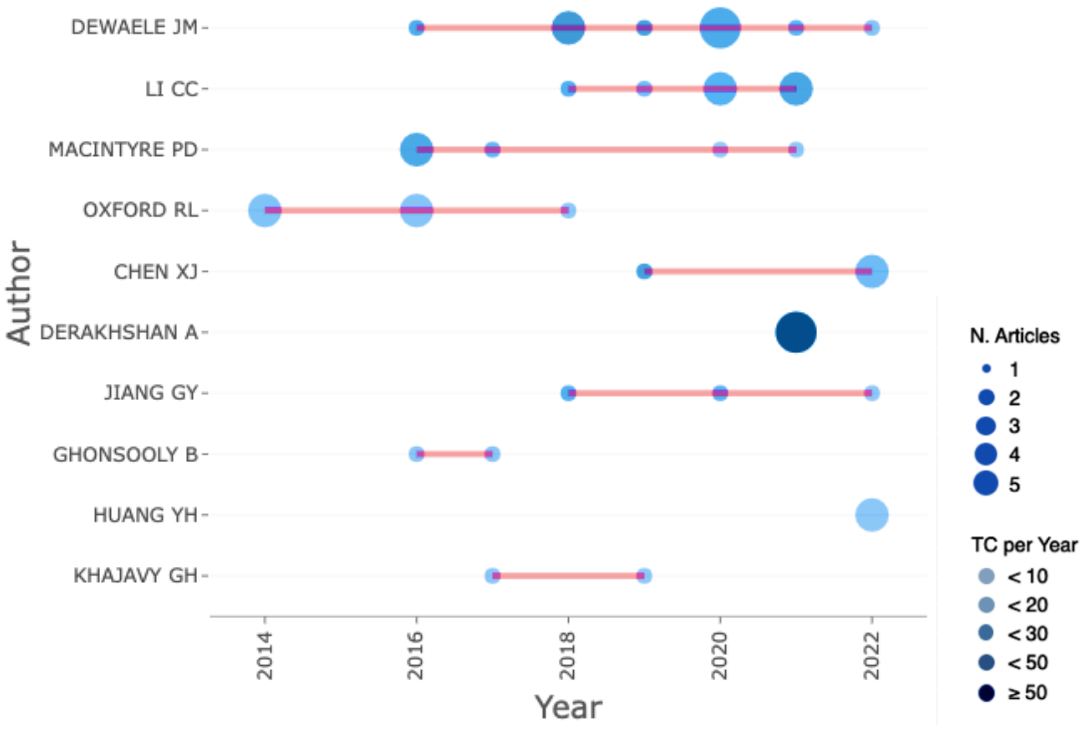
high level of research productivity, with both organizations producing 6 publications and receiving 908 and 193 citations respectively. The remaining five organizations in the top 10 list have contributed 5 publications each, and the final two organizations have contributed 4 publications each. However, it is important to note that the number of publications does not necessarily indicate the quality or impact of the research. Further analysis, such as citation impact and the scope of the research, should be conducted to fully evaluate the contributions of these organizations in this field.

Most Productive Authors

When assessing an author's significance within a particular field, it is important to consider both their productivity and impact. The productivity of an author is evaluated based on the number of articles they have published within a certain time frame. Impact, on the other hand, is determined by the number of citations received by an author per year. Figure 3 illustrates the production of the top authors over time. It should be noted that the size of the circles represents the number of articles published by the author in a specific year, with larger circles indicating a higher number of publications. Additionally, the darkness of the circles represents the number of citations received per year, with darker circles indicating a higher number of citations. From the data presented in Figure 2, Dewaele, Li, Oxford and Macintyre are the most productive authors in the field, while Derakshan received the highest number of citations per year after Dewaele. Additionally, Dewaele is a leading author in the field, with a consistent record of publications from 2016 to 2022.

Figure 2

Top Authors' Production Over Time



However, it is important to note that productivity alone is not a sufficient indicator of the overall quality of an author's work. Therefore, in Table 4, a thorough examination of the most prolific authors in the field of PP within FL education research is presented and two additional measures are provided to evaluate the top 10 most productive authors: the total citation number (TC), and the h-index. Furthermore, the table also includes details on the authors' affiliated institutions and countries, as well as their total number of publications (TP) and the number of citations associated with these publications (TC).

The authors with the highest number of citations in the dataset are Dewaele (TC = 782) and Derakshan (TC = 354), followed by Li (TC = 342) and Macintyre (TC = 341). Dewaele also demonstrates the best combination of productivity and impact, with 10 TP and an h-index of 7, indicating that he has published 7 articles that have received at least 7 citations. Li and Oxford have also performed well, with 6 and 5 total publications respectively and a h-index of 5. The overall results indicate that this is an emerging area with significant potential for future research.

Table 4

The Top 10 Most Influential Authors between 2012 and 2022

Rank	Author	Affiliation	Country	TP	TC	h-Index
1	Dewaele, J.M.	University of London	UK	10	782	7
2	Li, C.C.	Huazhong University of Science & Technology	China	6	342	5
3	Oxford, R.L.	University System of Maryland	USA	5	91	5
4	Macintyre, P.D.	Cape Breton University	Canada	5	341	4
5	Chen, X.J.	Tsinghua University	China	3	201	3
6	Derakhshan, A.	Golestan Univ	Iran	3	354	3
7	Ghonsooly, B.	Ferdowsi University Mashhad	Iran	2	32	2
8	Jiang, G.Y.	Shihezi University	China	3	202	2
9	Khajavy, G.H.	University of Bojnord	Iran	2	22	2
10	Lee, J.S.	Education University of Hong Kong	Japan	2	22	2

The present study found that a total of 254 out of 280 authors conducted a single publication on PP in the field of FLE. Additionally, an analysis of the productivity of authors revealed that one researcher had an exceptional level of productivity, having conducted ten studies on the topic. Another researcher also demonstrated a high level of productivity, having conducted six studies. These findings are further illustrated in Table 5, which provides a comprehensive breakdown of the productivity of authors in this field.

Table 5

Productivity of Authors

Documents written	Number of Authors
1	254
2	18
3	4
5	2
6	1
10	1

Most Influential Sources

The current study aimed to investigate the sources in which research on PP in FL education is preferred and published by researchers. A total of 42 different sources were identified, however, only the top ten sources were selected for further analysis. The sources related to PP in FL education, along with the number of publications indexed in WoS, were obtained. It was found that the most prominent source was *Frontiers in Psychology* (*n* = 53). Figure 3 provides an in-depth analysis of the most influential sources. Additionally, an examination of the source growth per year was conducted to compare the sources and their growth. Figure 4 illustrates the annual source growth, revealing an increasing interest in PP in FL education since 2020 which suggests a growing trend in this area of research.

Figure 3

Sources of Publication

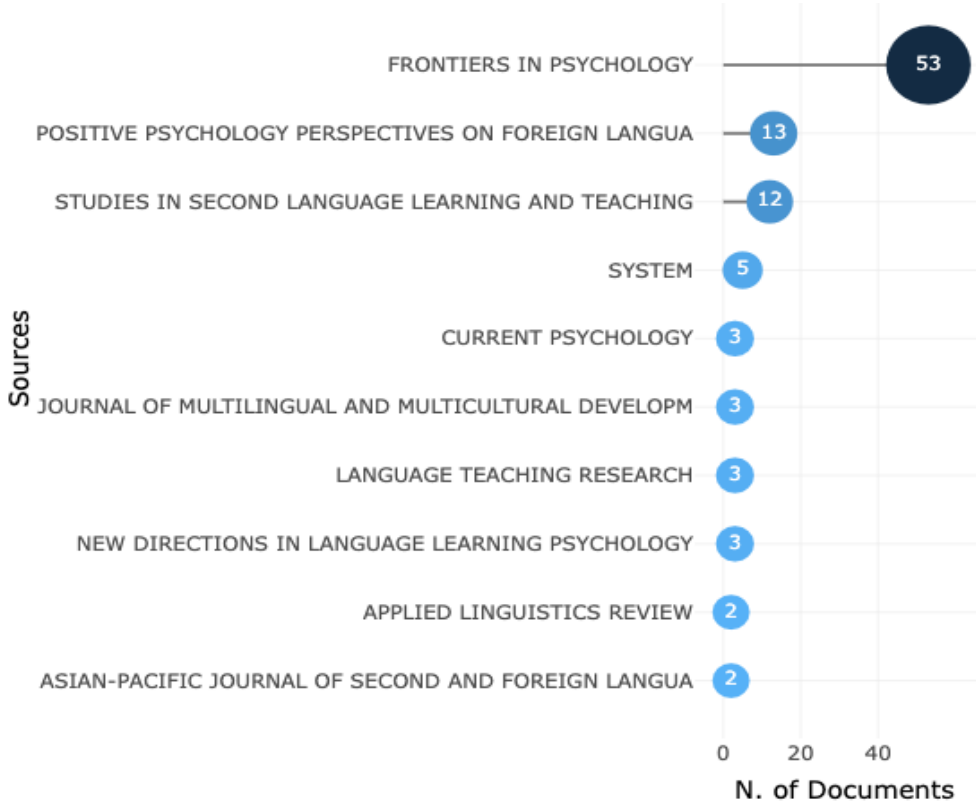
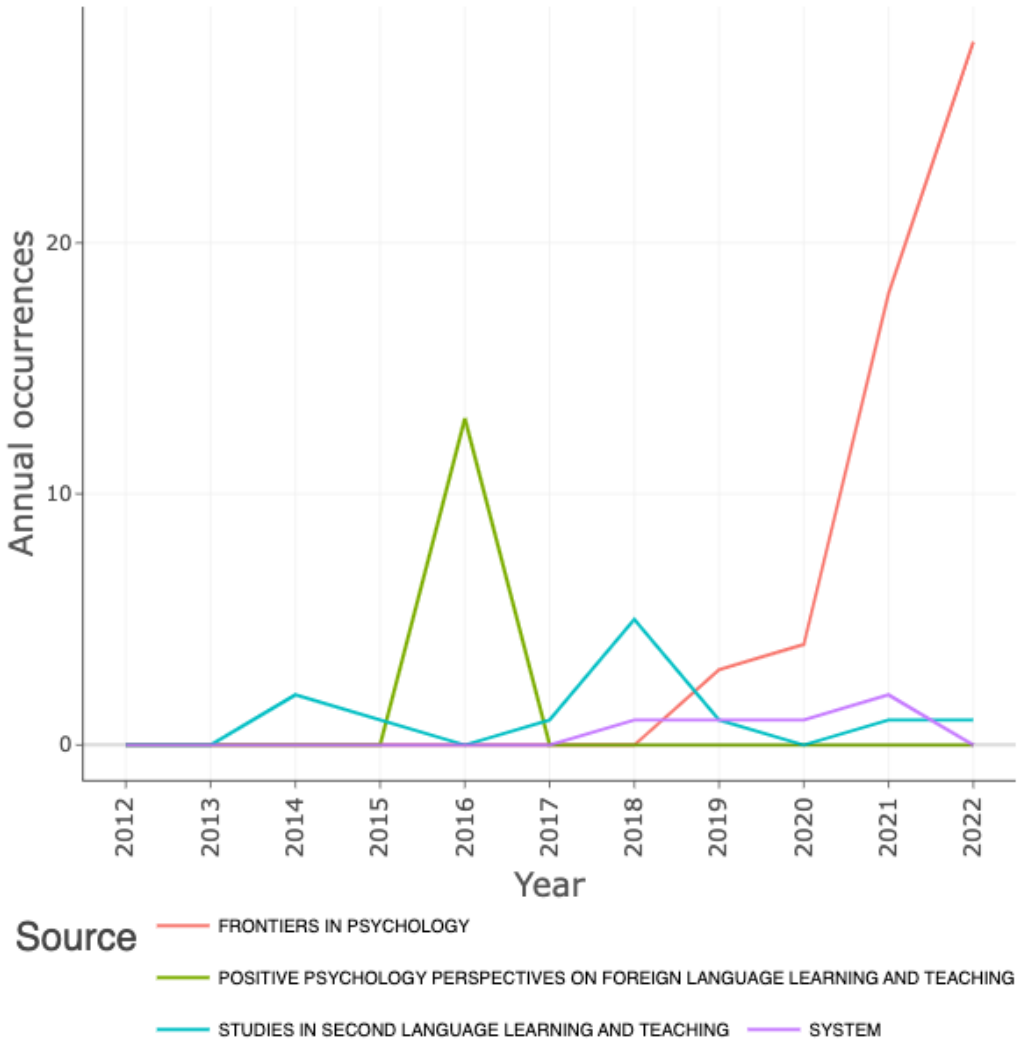


Figure 4

Source Growth per Year



Major Themes and Most Frequent Words

In a detailed examination of FL education publications, it was determined that the three most frequently used keywords among researchers are "positive psychology," "anxiety," and "emotions" which were cited 39, 37 and 31 times respectively. PP, which focuses on the study of positive emotions, well-being, and human strengths, has been a growing area of interest in the field of education, particularly in the context of language learning. The high frequency of this keyword in publications indicates the increasing attention being paid to the role of positive emotions in language learning and the development of students' overall well-being.

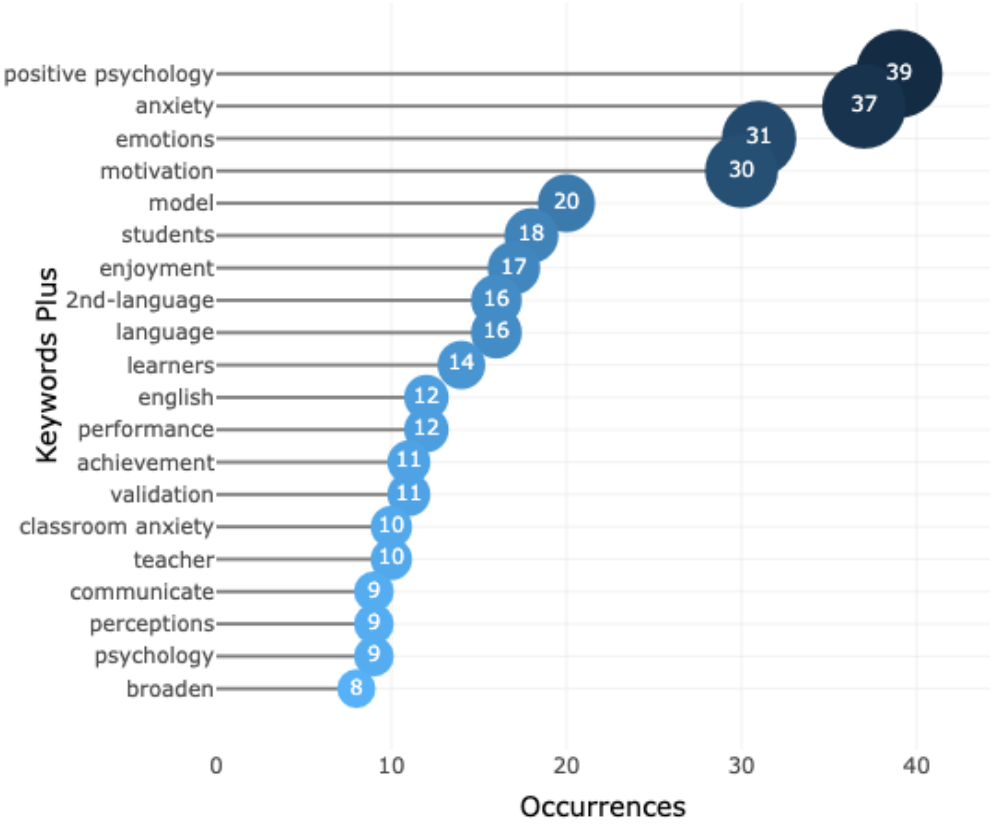
The frequent use of the term "anxiety" in language acquisition research may suggest a preoccupation with the study of negative emotions. However, scholars have recently directed their attention towards the examination of emotions in the context of FLL and teaching. This shift has prompted investigations into the impact of emotional states on language acquisition, extending beyond the conventional concepts of foreign language anxiety and motivation that were previously established in the field. Emotions, in general, have been acknowledged as a critical component of language learning, and

the high frequency of this keyword highlights the importance of understanding the emotional dimensions of language education.

The data on the most frequently used keywords is further visualized in Figures 5 and 6, which highlight the most prominent words and themes in the field. This visual representation allows for a clear understanding of the key concepts and themes that researchers are focusing on in their studies.

Figure 5

The Most Frequent Words and Top Twenty Themes



In addition to the analysis of the most frequently used keywords, an examination of the author's keywords (designated as "DE") revealed that there was a total of 476 keywords used in the publications. The top 50 of these keywords are depicted in Figure 6, providing a comprehensive overview of the research trends in the field. The utilization of multiple keywords in research articles was found to be a crucial factor in determining current trends in the field. It allows researchers to explore different aspects of the topic and provide a holistic understanding of the area of study.

The analysis conducted revealed that the most frequently used author keywords in the realm of foreign language (FL) education were "positive psychology", "emotion", and "foreign language enjoyment", accounting for 35 (14%), 28 (11%), and 28 (11%) frequencies, respectively. This finding underscores the fundamental role that these concepts play in the context of language education and the criticality of comprehending the affective aspects of language acquisition. The overall investigation of the themes and keywords in FL education literature offers essential knowledge into the present research advancements and the areas that necessitate further.

Figure 6

Tree Map of Author Keywords on Positive Psychology in FL Education

Trend Topics per Year

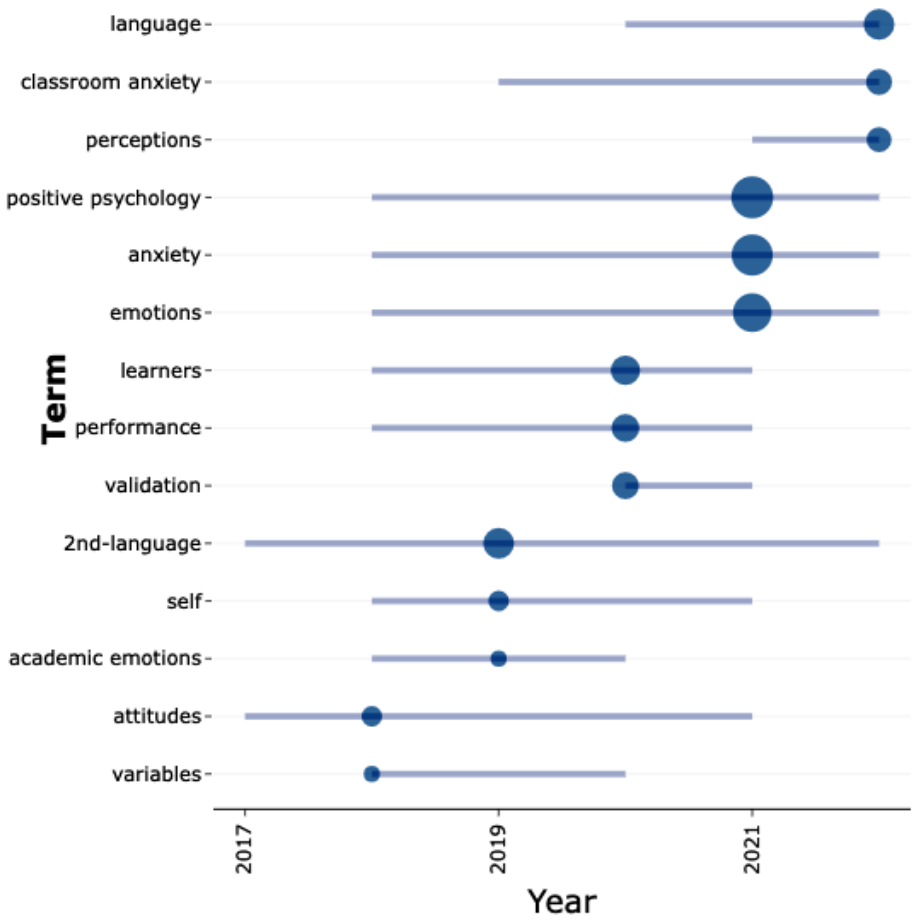
An in-depth analysis of the research trends in PP within the field of FL education has revealed a dynamic and evolving landscape. Examination of Figure 7 illustrates the shifting focus of trend topics throughout the years. In 2019, the trend topic of second language emerged, introducing the trend topic of validation in 2020, followed by a focus on learners and performance. In 2021, the trend shifted towards the topic of PP, anxiety, and emotions which have become the major trend. And in 2022, we can see that the trend topics have shifted once again, with language, classroom anxiety, and perceptions receiving growing attention. This dynamic shift in trend topics highlights the ongoing evolution of the field and the need for continued research to explore the various dimensions of PP in FL education. The emergence of new trend topics, such as validation in 2020 and classroom anxiety and perceptions in 2022, indicates a growing recognition of the importance of these areas in language education and the need for further research to understand their impact on language learning. As seen in 2021, for instance, the shifted focus in 2021 towards the major topic trends of PP, anxiety, and emotions, can imply that researchers were beginning to delve deeper into these areas of study. Moreover, the emergence of language, classroom anxiety, and perceptions as trend topics in 2022 suggests that researchers are now exploring the specific ways in which PP, anxiety, and emotions impact language learning in the classroom setting, as well as the perceptions of language learners and teachers. Furthermore, the consistent presence of the major topics of PP, anxiety, and emotions throughout the years highlights the ongoing significance of these areas in the field.

Overall, the analysis of the research trends provides valuable insights into the current state of research in the field as well as the areas that require further exploration.

It also serves as a reminder of the dynamic nature of the field and the need for continued research to keep pace with the ever-evolving landscape of FL education.

Figure 7

Trend Topics of Positive Psychology in FL Education



Systematic Literature Review

In the field of PP, we can see in Table 6 that the most cited publications are amongst studies that have focused on conceptual and comprehensive reviews. This trend can be attributed to several factors. To begin, conceptual reviews offer a comprehensive analysis of the literature of a certain topic or concept in the field. They include an overview of current research, highlighting key findings, gaps in the literature, and future research directions. These reviews are a valuable resource for scholars, practitioners, and policymakers since they give a thorough grasp of a certain field of study. Additionally, the increased interest in PP as a subject of research has resulted in a rise in the number of studies being undertaken on a range of issues. As a result, there is an increasing demand for conceptual and comprehensive assessments that synthesize and integrate this expanding body of information.

To identify possible study directions on PP in FLE, we conducted a systematic literature review on the top 10 cited publications published in respected journals of education and psychology. Due to this, we were able to pinpoint two key areas of

research: PP and emotions, which will be analyzed below. These key areas were also identified as major themes in Figure 7.

Table 6

The Overview of the Key Studies Reviewed

Article	Key Constructs	Theories	Characteristics	Context	Methodology
Wang et al., 2021.	The article provides an overview of the past, current, and future directions of research and practice of PP in second/foreign language learning and teaching.	Broaden-and-Build Theory of Positive Emotions (Fredrickson, 2004)	The article suggests key factors for empirical investigations and evidence in PP interventions in language learning and teaching: · Mechanisms of PP interventions · Effective implementation methods · Impact on different groups of learners · Long-term effects on learning outcomes · Use of technology, such as VR and gamification · Integration into curriculum, syllabus design, and assessment	Second/foreign language learning and teaching.	A conceptual review
Dewaele et al., 2016.	The article explores the correlation between FLE and classroom anxiety on language learners and their effects on motivation and learning outcomes.	Broaden-and-Build Theory of Positive Emotions (Fredrickson, 2004)	The study discovered a positive correlation between FLE and proficiency, and negative correlation between foreign language anxiety and proficiency. It also revealed gender and cultural differences in these factors. To enhance FL proficiency, the article suggests addressing anxiety and promoting enjoyment in the classroom.	1742 multilinguals between ages 11 to 75	Convergent parallel design, Online questionnaire
Dewaele, et al., 2019.	The article examines the use of PP in research on foreign language teaching and acquisition.	Positive Psychology	The authors contend that using PP in foreign language education can benefit learners' motivation, engagement, and well-being, while also boosting their self-esteem and language proficiency. However, further research is required to fully comprehend its advantages, as evidenced by the reviewed studies.	Second/foreign language learning and teaching	A Comprehensive Review
Dewaele, & Alfawzan, 2018.	The article discusses the question of whether the positive effect of enjoyment in FLL outweighs the negative effect of anxiety.	Positive Psychology	It is suggested that enjoyment can have a positive impact on language performance by increasing motivation, engagement, and attention, while anxiety can have a negative impact by causing stress, negative self-talk, and decreased motivation. These emotions were found to be influential in the decision to continue or stop studying English, and ultimately contributed to the level of proficiency in the language. In addition, teaching methods and practices were often reported to be the main causes of anxiety and enjoyment in learning English.	British secondary school students in the UK and adult university students in Saudi Arabia	Online Questionnaire

Article	Key Constructs	Theories	Characteristics	Context	Methodology
Li et al., 2018.	The article discusses the validation of the Chinese version of the Foreign Language Enjoyment scale.	Positive Psychology	The study links Chinese high school students' enjoyment of FLL to the teacher, learner, and classroom atmosphere, with the teacher having control. It notes that Chinese culture values power and authority, resulting in students being accustomed to teacher-centered activities. Overall, the study suggests that the Chinese version of the Foreign Language Enjoyment scale is a reliable and valid tool for measuring enjoyment in Chinese high school students learning a FL.	2000 Students from three high schools at different academic levels in China	Questionnaire
Xie & Derakhshan, 2021.	The article discusses the concept of positive teacher interpersonal communication behaviors in the classroom setting.	Positive Psychology	The article reviews positive communication behaviors, such as active listening, effective feedback, and emotional support, and their impact on student engagement and motivation. Understanding cultural and individual differences in communication styles and ongoing professional development are also highlighted. Overall, the article emphasizes the crucial role of positive teacher interpersonal communication in promoting student success.	Second/foreign language learning and teaching.	A conceptual analysis
MacIntyre & Vincze, 2017.	The article explores the impact of emotions on motivation for learning a L2	Positive Psychology and Differential Emotions Theory (Izard, 2007)	The study delves into several motivational concepts such as integrative orientation, L2 ideal/ought-to self, learning efforts, self-confidence, anxiety, perceived competence, contact with language speakers, and psychological acculturation. The study explores how these factors affect engagement in L2 learning and concludes that effective language instruction requires addressing both types of emotions to promote language learning motivation.	182 students in Italian language secondary schools	Scales
Li, Dewaele, & Jiang, 2020.	The article discusses the relationship between emotions in the classroom and EFL achievement in China.	Complex Dynamic Systems Theory and Positive Psychology	The study explores how FLCA and FLE affect self-perceived and actual English proficiency, as well as the impact of EA on FLE and FLCA. Positive emotions, emotional intelligence, and a positive classroom environment were found to enhance emotional well-being and EFL achievement. FLCA was a better predictor of English proficiency and achievement than FLE.	1,307 Chinese high school students	Exploratory Mixed-Method Approach Questionnaires
Piniel & Albert, 2018.	The article discusses the emotions that advanced FL learners experience in relation to the four skills of language acquisition.	Positive Psychology	Advanced language learners experienced positive emotions (e.g., motivation and satisfaction) while practicing all four skills, but negative emotions (e.g., frustration and anxiety) while speaking and listening. The study recommends providing learners with additional support and coping strategies for addressing these negative emotions and enhancing their language proficiency.	348 EFL students of higher education in Budapest, Hungary	Qualitative Approach Open-ended Questionnaires

Article	Key Constructs	Theories	Characteristics	Context	Methodology
Shao, Pekrun, & Nicholson, 2019.	The article explores the significance of emotions in classroom language learning, focusing on achievement emotions and the insights gained from related research.	Control-Value Theory (CVT)	The article advises teachers to foster positive emotions in the classroom by setting clear goals, offering feedback, and promoting autonomy, self-regulation, and a sense of belonging among students as emotions are crucial in language learning, and positive ones like enjoyment and satisfaction can enhance motivation and engagement, whereas negative ones like anxiety and boredom can impede it. Teachers should understand and manage these emotions and create a supportive learning environment to promote competence.	Second language acquisition	A conceptual analysis

Positive Psychology

PP has been identified as a potential holistic approach to FLL and teaching. This approach focuses on promoting well-being, motivation, and engagement among learners, which can enhance language proficiency and performance. Furthermore, it is becoming more and more important in the teaching of foreign languages. The focus of this field of research is to comprehend how individuals may cultivate and maintain positive emotions, wellbeing, and resilience in the face of adversity. This includes the shift from negative emotions towards the examination of how positive emotions, such as joy and gratitude, can enhance motivation and language performance, as well as the role of character strengths, such as curiosity and perseverance, in language learning success (Dewaele & MacIntyre, 2014; MacIntyre & Gregersen, 2012). PP research has demonstrated that students who have a positive attitude and perceive they can learn a new language are more likely to be successful (Dewaele et al., 2019). Positive emotions, including enjoyment and interest, have also been shown to be correlated with language acquisition results (Li et al., 2018). As a result, adding PP concepts into the teaching of foreign languages can support students' positive attitude development and enhance their language learning outcomes. One key area for further investigation is needed on the specific mechanisms through which PP interventions can enhance language learning and teaching. Effective implementation methods, impact on different learner groups, and long-term outcomes also require attention (Wang et al., 2021). Moreover, integrating technology, such as virtual reality and gamification, in PP interventions is another area of interest in which further research is necessary. The literature on virtual language instruction has demonstrated the significance of incorporating positive educational components. In this vein, future research should investigate the impact of factors such as resilience, loving pedagogy, well-being, engagement, grit, and enjoyment on language learning and teaching experiences in both conventional and digital contexts (Wang et al., 2021) to provide a deeper understanding of how the integration of these elements may enhance the overall effectiveness of language instruction.

Emotions

From the systematic review in Table 6, it can be seen that foreign language classroom anxiety (FLCA) and foreign language anxiety (FLA) in relation to enjoyment have been the center of focus. Recent literature has demonstrated a shift in focus

towards the examination of positive emotions, which can be attributed to the emergence of PP as a field of study (Seligman & Csíkszentmihályi, 2000). Research has revealed that positive emotions play a crucial role in the acquisition of second and foreign languages (Dewaele & MacIntyre, 2014; MacIntyre & Gregersen, 2012; MacIntyre & Vincze, 2017). According to Fredrickson's (2003, 2008) broaden-and-build theory, the experience of negative emotions is associated with a limited cognitive and behavioral focus, whereas positive emotions are associated with an expansion of an individual's cognitive and behavioral repertoire, leading to the cultivation and enhancement of physical, intellectual, social, and psychological resources. Therefore, the study of positive emotions in educational contexts can be considered a paramount of importance, as it plays a significant role in the acquisition of knowledge and skills.

Furthermore, emotions can also affect the teaching and learning process, as teachers' emotions can influence their teaching behavior and the classroom atmosphere, which, in turn, can affect the teaching and learning process. For instance, research shows that FLE among Chinese high school students is linked to the teacher, learner, and classroom atmosphere established by interactions among them, with the teacher having the most control (Li et al., 2018). However, ESL/EFL teachers' emotional and personal investments in their professional performance have been neglected, and this has a negative impact on their well-being. Effective language teaching involves more than just imparting content and pedagogical knowledge and implementing cutting-edge teaching methods and techniques (Pishghadam et al., 2019); it also entails an emotionally charged endeavor where language teachers interact and communicate with each learner while passionately presenting the subject matter in an enjoyable learning environment (Xie & Derakhshan, 2021). The development and establishment of positive teacher-student relationships is essential for successful teaching and learning processes and desired outcomes which are facilitated using effective interpersonal communication tactics (Delos Reyes & Torio, 2020; Houser & Hosek, 2018). Moreover, the cultural backgrounds influence these interactions, making it imperative to comprehend the extent to which teacher-student interpersonal communication behaviors are perceived, enacted, and experienced in a similar or dissimilar manner across different cultural contexts. The fifth and sixth principles of the rhetorical and relational goal theory, which postulates that teachers' rhetorical and relational objectives and students' academic and relational requirements differ across situations and age levels, are in support of this claim (Xie & Derakhshan, 2021). The methods used to meet and accomplish these demands and goals also vary, emphasizing the need to study these issues in various geographical and cultural contexts (Houser & Hosek, 2018).

In essence, PP and emotions are the key areas of research which play a crucial role in our understanding of FLL and teaching. By incorporating the principles and findings from these areas of research, educators can create a more positive and supportive learning environment for their students, which can lead to improved language learning outcomes. Additionally, further research in these areas can also contribute to the development of more effective and efficient language teaching methods. From this point, instead of utilizing large-scale studies that gather data from extensive samples to enhance the generalizability of findings, future research could focus on examining the perceptions or experiences of a limited number of cases and collect rich data (Dörnyei, 2007). Longitudinal studies would also be advantageous in

this realm, as they demonstrate how individuals' perceptions, experiences, or behaviors evolve or remain constant over time. With cross-sectional studies being the prevalent methodology in the field, it is imperative to incorporate more longitudinal designs to make more conclusive causal inferences (Lazarus, 2003). Furthermore, there is a need for more PP-inspired interventional studies in foreign language classrooms, utilizing a diverse array of approaches, that aim to enhance learners' linguistic abilities and well-being (MacIntyre et al., 2019; Wang et al., 2021).

Conclusion

This study employed a bibliometric analysis to investigate the current state of research on PP in the FL context, highlighting the growing interest and potential for this approach to enhance language learning and development. It is noteworthy that there is a dearth of research on this topic, as evidenced by the statistics, which indicate that there has been a total of 137 publications in the WoS database between 2012 and 2022. The identification of key trends, patterns, and areas for future research in this field highlights the importance of continued exploration and investigation in this area. The analysis of citation patterns within PP publications in the FL context provides valuable insights into the current state, the contributions of specific authors, institutions, and countries and the significant impact they have on shaping the field. Overall, the current study provides a comprehensive map of the relevant studies on PP in the FL education context, which may serve as a valuable resource for scholars and practitioners. The recent emergence of PP as a significant research area is particularly surprising given that psychology plays a significant role in fostering a more positive and successful language learning experience by promoting psychological well-being and a growth mindset (Dörnyei, 2009). Yet, despite the potential contributions that PP can make to the field, research in this area has been limited. According to PP principles, understanding how positive educational factors contribute to learners' flourishing across diverse cultural and instructional contexts is crucial (MacIntyre, 2021). Hence, there is a clear call for more comprehensive cross-cultural studies that delve into various positive educational variables to enrich our understanding (Wang et al., 2021). Empirical studies in PP within L2 education have predominantly relied on quantitative methods, often using closed-ended questionnaires, which may limit the depth of insights gained (Derakhshan, 2021; Khajavy, 2021). To address these limitations, future research should embrace qualitative and mixed methods approaches to capture more nuanced and real-time data (Dewaele & Pavelescu, 2021). Additionally, longitudinal studies could offer valuable insights into how these positive educational variables evolve over time in educational settings (Dewaele et al., 2022). Cross-cultural research in PP within L2 education is also relatively sparse, despite some international studies (Dewaele & MacIntyre, 2014, 2019; Dewaele et al., 2022). Exploring how positive emotions and traits manifest across different cultural backgrounds is essential for developing culturally responsive educational strategies (Pishghadam et al., 2021). Addressing this gap could lead to more inclusive and effective educational practices that cater to diverse learner needs and contexts globally.

Therefore, while PP holds promise for enhancing L2 learning experiences through positive psychological interventions, there remains a critical need for further research. By adopting diverse research methodologies, including qualitative approaches

and cross-cultural studies, scholars can deepen our understanding of how positive educational factors contribute to successful language learning outcomes worldwide. This interdisciplinary approach not only enriches educational theory but also informs practical strategies for educators aiming to foster resilience, engagement, and well-being among L2 learners and educators alike. Thus, the scarcity of research in this area serves as a call to action for researchers to prioritize and expand their investigations, recognizing and addressing the neglect of this research area in the past.

To conclude, it is hoped that this analysis will contribute to the ongoing efforts to understand and improve the language learning experience for both students and teachers. Notably, one limitation of the present study is that it is focused solely on bibliometric analysis of publications indexed in the WoS database. While this methodology provides a useful perspective on the state of PP research in the context of FLE, it is important to note that there may be other valuable insights that can be gleaned from investigating publications outside of the WoS database. Additionally, it is crucial to recognize that bibliometric indicators, such as citation count and journal impact factor, are not the only measures of publication quality. Therefore, it would be beneficial for future research to expand the scope of the investigation to include publications from a wider range of sources to gain a more comprehensive understanding of the field.

Statement of Responsibility

Naile Canlı: Methodology, data analysis and interpretation, writing-original draft, visualization. Devrim Höl: Validation, writing-review and editing, supervision.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

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The Effect of Innovative Schools and Schools' Openness to Change on Teachers' Adaptive Performance*

Yenilikçi Okul ve Okulların Değişime Açıklığının Öğretmenlerin Uyumsal Performansına Etkisi

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ABSTRACT: In this study, it was aimed to examine the effect of teachers' perceptions of innovative schools and schools' openness to change on their perceptions of adaptive performance. Predictive correlational design was used in the study. Simple random sampling method was utilized to determine the sample. The sample consisted of 258 teachers. *Personal Information Form, Innovative School Scale, Schools' Openness to Change Scale and Teachers' Perceived Adaptive Performance Scale* were applied to collect the data. In data analysis, descriptive statistics, Pearson correlation and hierarchical regression analysis were used. In the study, teachers' perceptions of innovative schools and adaptive performance were found to be high, and their perceptions of schools' openness to change were found to be moderate. It was determined that innovative school and schools' openness to change together significantly predicted adaptive performance. It was determined that the dimensions of organizational impediments, teachers' openness to change and school environment's press for change were significant predictors of adaptive performance while innovative schools and schools' openness to change were together. It was concluded that in order to increase the adaptive performance of teachers, it is necessary to realize innovative practices in schools and to increase the openness of schools to change. Suggestions were made to prevent the factors that hinder innovations in schools and to increase the openness to change of teachers and the school environment.

Keywords: Adaptive performance, innovative school, openness to change, teacher.

ÖZ: Bu araştırmada, öğretmenlerin yenilikçi okul ve okulların değişime açıklık algılarının uyumsal performans algılarına etkisini incelemek amaçlanmıştır. Araştırmada yordayıcı korelasyonel desen kullanılmıştır. Örneklemin belirlenmesinde basit tesadüfi örnekleme yöntemi kullanılmıştır. Örneklemi 258 öğretmen oluşturmuştur. Verilerinin toplanmasında *Kişisel Bilgi Formu, Yenilikçi Okul Ölçeği, Okulların Değişime Açıklık Ölçeği* ve *Öğretmenlerin Algıladıkları Uyumsal Performans Ölçeği* kullanılmıştır. Verilerin analizinde betimsel istatistik, Pearson korelasyon ve hiyerarşik regresyon analizi kullanılmıştır. Araştırmada, öğretmenlerin yenilikçi okul ve uyumsal performans algıları yüksek, okulların değişime açıklık algıları orta düzeyde bulunmuştur. Yenilikçi okul ile okulların değişime açıklığının birlikte uyumsal performansı anlamlı bir şekilde yordadığı belirlenmiştir. Yenilikçi okul ile okulların değişime açıklığının birlikte iken *Örgütsel engeller*, *Öğretmenlerin değişime açıklığı* ve *Okul çevresinin değişim baskısı* boyutlarının uyumsal performansın anlamlı yordayıcıları olduğu belirlenmiştir. Öğretmenlerin uyumsal performanslarının daha fazla artması için hem okullarda yenilikçi uygulamaların gerçekleştirilmesinin hem de okulların değişime açıklığının arttırılmasının gerekli olduğu sonucuna ulaşılmıştır. Okullarda yeniliklerin engellenmesine neden olan faktörlerin önlenmesine, öğretmenlerin ve okul çevresinin değişime açıklığının arttırılmasına yönelik öneriler sunulmuştur.

Anahtar kelimeler: Değişime açıklık, öğretmen, uyumsal performans, yenilikçi okul.

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In order for organizations to survive, it is imperative that they adapt to the changes occurring in their environment. Due to this necessity, organizations make many changes in their structures, processes and methods. However, for the effectiveness of these changes, attention should be paid to equipping employees with the knowledge and skills that will require them to adapt to changes (Tunçer, 2012). This is because the inability of employees to adapt to their work environment can negatively affect their work performance and jeopardize the success and continuity of the organization (Tümkaya & Hürriyetoğlu, 2021). Therefore, adaptable employees are an organizational need in organizations with changing and dynamic environments. This need has increased the interest in understanding and increasing the adaptability of employees in the work environment with the increasing pace and types of change (Pulakos et al., 2000). As a result of this interest, employees' ability to cope with changes in the work environment has been emphasized (Wanberg & Banas, 2000) and it has been realized that traditional performance models are inadequate. Thus, adaptive performance, which refers to responding to changing job requirements, has been emphasized to determine the performance of employees under variable and uncertain conditions (Jundt et al., 2015). In this respect, adaptive performance was introduced as a dimension of job performance in line with the need to encourage new behaviors to achieve the goals of organizations as a result of changes in the work context (Charbonnier-Voirin & Roussel, 2012).

Adaptive performance is important for educational organizations where change and transformation are continuous. In particular, teachers' adaptive performance is emphasized in order to adapt to changes and to achieve successful educational outcomes (Dilekçi & Sezgin-Nartgün, 2020a, 2020b). This is because teachers need to adapt to changes in curricula, programs, instruction, and educational policies. At the same time, classroom management, collaboration, and meeting the diverse and changing needs of students require adaptability (Collie & Martin, 2016). Accordingly, teachers' adaptive performance is important both in terms of implementing changes in education and the nature of the teaching profession, which requires interpersonal adaptability and appropriate behaviors in variable situations. Therefore, it is pointed out that adaptability is an important criterion for effective teaching (Collie & Martin, 2016; Loughland & Alonzo, 2019). Indeed, Andres et al. (2021) found that teachers with high adaptability also had high levels of teaching performance. Brühwiler and Vogt (2020) found that teachers' adaptive teaching competencies positively affect student achievement not directly but through high-quality classroom processes. All these indicate that it is necessary for teachers to have a high level of adaptive performance. Therefore, it is important to create conditions that will ensure teachers' adaptive performance. These conditions can be created by identifying the factors that affect teachers' adaptive performance.

In related literature, it was determined that school culture (Kuş, 2023), teaching mood (Dilekçi, 2018), organizational climate, knowledge sharing behavior and innovative work behavior (Irawan & Sudibjo, 2022) affect teachers' adaptive performance. Considering the studies, it can be said that there are few studies on the factors affecting teachers' adaptive performance. However, since many individual and contextual factors can affect teachers' adaptive performance, more research is needed. Similarly, Dilekçi and Sezgin-Nartgün (2020a) stated that adaptive performance has

been neglected in the context of educational organizations and teachers and suggested more research. On the other hand, Park and Park (2019) examined the research on adaptive performance. It was pointed out that the first studies were mostly conducted in the field of psychology. They determined that the researches focused more on individual-level factors and suggested that research on contextual factors should be conducted. They also stated that the factors that increase adaptive performance should be further investigated to determine how to increase the adaptive capabilities of organizations in today's changing environments. In this respect, it was thought that conducting contextual research that affects teachers' adaptive performance is important in terms of contributing to the literature. With this in mind, in this study, the contextual factors of innovative schools and schools' openness to change are addressed. This is because the main foci of innovative schools, schools' openness to change and adaptive performance are change. Although their focal points are the same, the relationship between them is not clear. Empirical evidence is needed to elaborate this relationship.

In this study, it was aimed to examine the effect of teachers' perceptions of innovative schools and schools' openness to change on their perceptions of adaptive performance. In addition, it was thought that the findings to be obtained by examining the level of teachers' perceptions of these variables and the relationship between these variables could provide detailed information that would contribute to increasing teachers' adaptive performance. The findings of this study can contribute to the literature in terms of revealing the innovativeness and openness to change of schools and teachers' adaptive performance according to teachers. In addition, the findings of this study can provide guidance to school principals on how to direct schools' openness to change and innovative school contexts in order to increase teachers' adaptive performance. On the other hand, increasing teachers' adaptive performance is important for the success of the changes that MoNE will implement to make schools more effective. Therefore, the findings of the study can guide MoNE's policies in schools.

Literature Review

Innovative School

Organizational innovation refers to efforts to improve organizational performance by changing the status quo and creating innovations in products, processes and services. Innovative schools also refer to innovations in schools (Meizatri et al., 2023) and aim to adopt contemporary approaches in education and provide students with a more effective learning experience (Williamson & Payton, 2009). According to Turan and Cansoy (2021), innovative school refers to a holistic educational approach that includes elements such as student-centered education, developing problem-solving skills, encouraging critical thinking and integrating technology effectively. It can be said that innovative schools break the shackles of traditional teaching methods by encouraging not only students but also teachers to be constantly open to innovations. Therefore, innovative schools can also be defined as representatives of a paradigm shift within the framework of traditional education.

The prevailing climate in the school is important for schools to adopt change and redefine the educational experience, that is, to effectively transform the structure of learning institutions (Çekmecelioğlu, 2006). Stonar and Wankel (1986) drew attention to the impact of a dynamic, flexible and innovative organizational climate on the

realization of innovations. Bharadwaj (2000), on the other hand, discussed the innovative climate in relation to the support of innovative and creative behaviors of organizational members. Another point to be emphasized at this point is the importance of administrative support in the development of an innovative school. As a matter of fact, the fact that the school administration has a visionary perspective in the process of shaping schools will contribute to the formation of an innovative school climate and will be effective in eliminating possible obstacles to innovation. Because, a management that is not supportive of innovation is one of the organizational barriers to innovation (Yeşil, 2018). In addition, regulations, standards and laws that do not encourage innovation, lack of financial support for innovation or ineffective government incentives (Guo et al., 2016; Hölzl & Janger, 2014; Patanakul & Pinto, 2014) can be listed as the main organizational barriers.

Schools' Openness to Change

Employees' attitudes towards change have an important role in determining the success or failure of changes in organizations. Employees may respond to change in a positive way such as excitement and happiness or in a negative way such as fear and anxiety. In this case, employees may have positive and negative attitudes towards change. While positive attitudes ensure that the change in the organization is supported by the employees and they exhibit behaviors towards success, negative attitudes cause employees to resist change and exhibit behaviors to sabotage change efforts (Gürbüz & Bayık, 2019). Therefore, employees' openness to change is important. Because, openness to change is defined as employees' readiness for change, cognitive and emotional acceptance of change and support for change (Bozbayındır & Alev, 2018). This definition shows that openness to change reflects the behaviors required by employees' positive attitudes towards change in the form of "positive influence and support for change and its consequences" (Sinval et al., 2021, p. 2). In this respect, schools that are open to change can be stated as schools where changes are supported and behaviors that contribute to the success of changes are realized.

Schools that are open to change aim to create a structure that is more responsive to student needs and adapts to the requirements of the age. For this reason, they provide teachers with continuous professional development opportunities and encourage them to update themselves and become more responsive to student needs. At this point, teachers can fulfill their active role in the change process by being self-confident, visionary and self-efficacious individuals who are not afraid of change. However, this responsibility does not only belong to teachers. In addition to teachers, school principals are also expected to support the change success of schools in this process (Çobanoğlu, 2006). Change supportive principals play an important role in promoting educational innovation and restructuring by creating a vision for the future and building a culture of collaboration (Kareem et al., 2023). Indeed, leaders are expected to assume the responsibility of leading and facilitating the change process (Küçüksüleymanoğlu & Terzioğlu, 2017). Due to this responsibility, Çelikten (2001) emphasizes the importance of the school principal's ability to successfully manage change in order to promote change and ensure its success. In this respect, the school principal should have the knowledge and skills of what kind of changes should be made in the school, what are the processes of change, and how to make employees' reactions to change positive.

However, the school principal should accept that change is a necessity for school effectiveness. With this understanding, in order to manage the change process successfully (Canlı et al., 2015), the principal should have effective leadership qualities that positively affect teachers' openness to change (Cerit et al., 2018). They should also be in constant communication with other stakeholders of the school to control and spread innovation and change (Zacharo et al., 2018). Because the fact that the school environment also wants change, provides the necessary support for the realization of change and even pressures the school to change are among the prerequisites for change to be achieved in schools (Demirtaş, 2012).

Adaptive Performance

It is noted that there are different definitions and conceptualizations of adaptive performance in the literature. Park and Park (2019) stated that there is no consistent definition of adaptive performance as it is addressed with different variables in different organizational contexts. However, they pointed out that the common point of different definitions is that they emphasize the work behaviors necessary to adapt to changes in the work environment. Jundt et al. (2015) revealed that different conceptualizations of adaptive performance have some common points. The first one is that adaptive performance is related to exogenous changes. In other words, adaptive performance arises when new roles are adopted, new skills are acquired, knowledge, skills and behaviors are adapted to new conditions and existing work behaviors are changed in relation to changing situations. The second, adaptive performance aims to maintain the employee's level of performance or minimize the decline in performance under changing work conditions. The third, adaptive performance involves learning and implementing new behaviors in anticipation of a new change and reactively in response to a sudden change in performance. The fourth, adaptive performance involves the adaptation of the employee to interpersonal and organizational changes as a result of changes in tasks as a result of interdependencies in the organization.

Adaptive performance requires employees to engage in certain behaviors in the work environment. For example, adaptive performance requires employees to adapt to, cope with and behave appropriately in unpredictable and uncertain situations. It also requires effective management of dangerous and emergency situations by making appropriate decisions and exhibiting appropriate behaviors. It necessitates finding creative and effective solutions to problems that arise or may arise. It involves employees to exhibit harmonious behaviors by adjusting their interpersonal behaviors to enable them to work in teams. It also requires integrating into a new culture and environment by performing adaptive behaviors to different people and cultures in order to perform effectively in different cultural contexts. This needs to learn the customs, values and rules of different cultures and demonstrate appropriate behaviors. It requires employees to be willing to learn new knowledge and acquire new skills required by the changes that occur in the performance of their duties and to adapt to new work processes and procedures by learning them. It needs employees to remain calm in challenging situations that arise due to change, manage stress that may occur, avoid overreacting and calm their colleagues. It requires the ability to adjust oneself to the physical conditions in which challenging tasks will be performed (Pulakos et al., 2000). In this respect, adaptive performance emphasizes behaviors related to competency

acquisition (Shoss et al., 2012) and reveals employees' ability to make cognitive, behavioral and affective changes in accordance with changing work environments (Demirkalp, 2022; Loughland & Alonzo, 2019).

Innovative School and Schools' Openness to Change

Change can be positive or negative. Organizations can develop with positive changes and become more effective in methods and processes. Negative changes, on the other hand, can cause deviations from organizational goals and a decrease in organizational effectiveness and efficiency (Tunçer, 2013). Positive changes are expressed as innovation (Özdaşlı, 2006). In this regard, it is important to be open to change in creating an innovative school (Riveras-León & Tomàs-Folch, 2020). Organizations that are open to change create a social context that enables employees to engage in proactive behaviors towards change and interact due to changes. It also creates an organizational climate that supports creativity. Such environments encourage employees to explore, take action and perform more innovatively (Curşeu et al., 2022). On the other hand**,** supporting innovation increases openness to change (Alayoğlu, 2019). In this respect, it can be stated that schools where innovations can be realized are open to change.

Innovative School and Adaptive Performance

Effective development and innovation practices in organizations depend on employees' readiness for and reaction to change (Töremen, 2002). Innovations can be successfully realized with individuals who are aware of their own knowledge and skills, can adapt to innovations and have learned to learn (Yüner & Özdemir, 2020). From this point of view, teachers' adaptive behaviors to change can contribute to the creation of a suitable environment for the realization of innovations in schools. On the other hand, in organizational environments where new ideas are supported, employees are more likely to take responsibility for change and innovation ideas. Because, an innovative organizational environment encourages employees to take responsibility in the change process and adapt to changing contexts by supporting, rewarding and empowering them (Park & Park, 2019). In respect to this, innovative schools can enable teachers to perform behaviors that are adaptive to change.

Schools' Openness to Change and Adaptive Performance

The reason why changes in organizations do not achieve the intended results is usually the failure of implementation. It is stated that change initiatives will fail especially when the attitudes and behaviors of individuals towards change are not sufficiently taken into account. The success of change can be possible by changing the attitudes and behaviors of employees positively in appropriate ways (Gürbüz & Bayık, 2019). Because successful changes can be realized together with employees and by taking into account the quality of employees. In this respect, organizations that can manage their human resources well can adapt to change more easily (Tunçer, 2012). Employees' adaptation to change can be achieved by being tolerant to changing conditions even in crisis situations and having an open attitude to change (Oganisjana et al., 2023). In this respect, teachers in schools open to change can be expected to adapt to change more easily.

Purpose of the Study

In this study, it was aimed to examine the effect of teachers' perceptions of innovative schools and schools' openness to change on their perceptions of adaptive performance. For this purpose, answers to the following questions were sought:

1. What is the level of teachers' perceptions of innovative schools, schools' openness to change and adaptive performance?
2. Is there a significant relationship between teachers' perceptions of innovative schools, schools' openness to change and adaptive performance?
3. Do teachers' perceptions of innovative schools significantly predict their perceptions of adaptive performance?
4. When the possible effects of teachers' perceptions of innovative schools are controlled, do their perceptions of schools' openness to change significantly predict their perceptions of adaptive performance?
5. Do teachers' perceptions of innovative schools and schools' openness to change together significantly predict their perceptions of adaptive performance?

Method

Research Design

In this study, a predictive correlational design belonging to the correlational survey model was used. Correlational survey is a research model designed to determine whether the variables in the study change together (Karasar, 2023), that is, whether there is a relationship between them and to explain the type of this relationship (Christensen et al., 2015) and to make predictions about the variables in question (Gliner et al., 2015). Predictive correlational design is a research design that allows to explain the changes in the dependent variable caused by the independent variable (Büyüköztürk et al., 2016).

Participants

Simple random sampling method was used to determine the sample in the study. Simple random sampling method, which is widely used in scientific researches, is used when the homogeneity of the universe is high. In this method, the individuals to be selected for sampling are randomly selected and the probability of sampling individuals in the universe is equal (Noor et al., 2022). The sample of this study consisted of 258 teachers working in public secondary schools in Niğde province in the 2020-2021 academic year. The demographic information of the participants is shown in Table 1.

Table 1

Demographic Information of the Participants

Variable	Group	*N*	%
Gender	Female	173	67.1
	Male	85	32.9
Marital Status	Married	172	66.7
	Single	86	33.3
Branch	Social sciences	93	36.0
	Science	71	27.5
	Other	94	36.4
Educational Level	Undergraduate	234	90.7
	Graduate	24	9.3
Location of School	Center	135	52.3
	Districts	123	47.7
Total		258	100

According to the Table 1, of the teachers, 67.1% (*n*=173) were female and 32.9% (*n*=85) were male. 66.7% (*n*=172) were married and 33.3% (*n*=86) were single. The branch variables of the teachers were grouped as social sciences (Social Sciences, Turkish and English), science (Science and Mathematics) and other (Visual Arts, Technology and Design, Religious Culture and Moral Knowledge, etc.). Of the teachers, 36% (*n*=93) were in social sciences, 27.5% (*n*=71) in science and 36.4% (*n*=94) in other fields. The educational level of the teachers was 90.7% (*n*=234) undergraduate and 9.3% (*n*=24) postgraduate. 52.3% (*n*=135) of the teachers work in the provincial centre and 47.7% (*n*=123) work in schools located in the districts.

Data Collection Tools

Personal Information Form, Innovative School Scale, Schools' Openness to Change Scale and *Teachers' Perceived Adaptive Performance Scale* were used to collect the research data.

Personal Information Form

It was used to collect information about teachers' educational status, gender, marital status, branch and the environment in which the school is located.

Innovative School Scale

It was used to determine teachers' perceptions about the innovation levels of schools. The scale was developed by Aslan and Kesik (2016). The scale has 19 items and three sub-dimensions (*Administrative support, Innovative atmosphere and Organizational impediments*). The total variance explained by the sub-dimensions in the scale is 62.70%. The fit index values of the scale are $\chi^2=360.38$, *Sd=146,* $\chi^2/Sd=2.46$, *GFI=.90, AGFI=.87, NNFI=.97, NFI=.95, CFI=.97, RMSEA=.055, SRMR=.069.* The Cronbach's Alpha value of the scale is .85 (Aslan & Kesik, 2016). In this study, the

Cronbach's Alpha value of the scale was found to be .93. The rating intervals in the scale are "Never (1), Rarely (2), Sometimes (3), Most of the time (4), Always (5)". In the interpretation of teachers' perceptions, "low" for 1-2.33, "moderate" for 2.34-3.66 and "high" for 3.67-5 were evaluated.

Schools' Openness to Change Scale

It was used to determine teachers' perceptions of their schools' openness to change. The scale was developed by Smith and Hoy (2007) and adapted into Turkish by Demirtaş (2012). The scale consists of a total of 14 items and three sub-dimensions (*Teachers' openness to change, Principals' openness to change, and School environment's press for change*). The total variance of the subscales in the scale is 59.32%. The total variance of the sub-dimensions in the scale is 59.32%. Cronbach's Alpha value of the scale is .78 (Demirtaş, 2012). In this study, Cronbach's Alpha value of the scale was found as .62. The rating intervals in the scale are "I completely disagree (1), I partially agree (2), I moderately agree (3), I mostly agree (4) and I completely agree (5)". In the interpretation of teachers' perceptions, "low" for 1-2.33, "moderate" for 2.34-3.66 and "high" for 3.67-5 were evaluated.

Teachers' Perceived Adaptive Performance Scale

It was used to determine teachers' perceptions of adaptive performance. The scale is the "Adaptive Performance" sub-dimension of the "Teachers Perceived Job Performance Scale/TPJP" scale developed by Bhat and Beri (2016). This sub-dimension was adapted into Turkish by Dilekçi and Sezgin-Nartgün (2020b). The scale consists of a total of 18 items and three sub-dimensions (*Inability to cope with problems, Managing unexpected situations, Interpersonal and cultural adaptability*). The total variance explained by the sub-dimensions is 55.53%. The fit index values of the scale are $x^2=418.53$, *Sd=132,* $x^2/Sd=3.17$, *GFI=.90; AGFI=.87; CFI=.97; NFI=.95; NNFI=.96; IFI=.97; RFI=.95.* The Cronbach's Alpha value of the scale is .88 (Dilekçi & Sezgin-Nartgün, 2020b). In this study, the Cronbach's Alpha value of the scale is .79. The rating intervals in the scale are "Never (1), Rarely (2), Occasionally (3), Frequently (4), Always (5)". In the interpretation of teachers' perceptions, "low" for 1-2.33, "moderate" for 2.34-3.66 and "high" for 3.67-5 were evaluated.

Data Collection Process

Before the data were collected Nigde Omer Halisdemir University Ethics Committee with the decision dated 28/07/2020 and numbered 07/01 and research permission was obtained from Niğde Provincial Directorate of National Education. Data collection tool was sent to 463 teachers working in public secondary schools in Niğde province. Due to the Covid-19 pandemic, data were collected online (message and e-mail). Feedback was received from 289 teachers.

Analysing the Data

Firstly, the data were analysed for outliers. The 31 measurement tools with outliers were not included in the analysis. The data analysis continued with the remaining 258 measurement tools. In order to decide on the analyses to be used, skewness and kurtosis values of the data were determined. Skewness and kurtosis values of the data are given in Table 2.

Table 2

Skewness and Kurtosis Values of the Data

Scales and Dimensions	Skewness	Kurtosis
Innovative Atmosphere	-1.095	1.216
Administrative Support	-.763	-.055
Organizational Impediments	.407	-.277
Innovative School Scale	-.412	-.570
Teachers' Openness to Change	-.872	.900
Principals Openness to Change	-.752	1.674
School Environment's Press for Change	-.588	-.404
Schools' Openness to Change	-.553	-.376
Managing Unexpected Situations	-1.084	1.096
Interpersonal and Cultural Adaptability	-1.941	2.907
Inability to Cope with Problems	.934	.904
Adaptive Performance Scale	-.854	.617

The skewness and kurtosis values indicated in Table 2 are within the values accepted for normal distribution of the data (Kline, 2011). Therefore, parametric tests were used in the data analysis. Descriptive statistical analysis was conducted for the first sub-problem of the research. The results of Pearson correlation analysis were utilized for the second sub-problem of the research. Hierarchical regression analysis was performed for the third, fourth, and fifth sub-problems of the research. Durbin-Watson values of 1.961 indicated no autocorrelation (Field, 2009). The correlation values between independent variables were less than .90. Tolerance values ranged from .216 to .897. VIF values ranged from 1.115 to 4.629. These values indicated no multicollinearity problem (Çokluk et al., 2012). In correlation analysis, values between 0.70-1.00 were interpreted as "high"; 0.69-0.30 as "moderate"; and 0.29-0.00 as "low" level. In regression analysis, values less than .09 were considered "low", values between .09 and .48 as "moderate", and values above .49 as "high" effect (Büyüköztürk, 2012).

Results

Descriptive statistical analysis was performed to determine the level of teachers' perception of innovative schools, schools' openness to change and adaptive performance. The results of the descriptive statistical analysis are presented in Table 3.

Table 3

Teachers' Perception of Innovative School, Schools' Openness to Change and Adaptive Performance

Scales	*n*	*Min.*	*Max.*	$\bar{X}$	*sd*	*Level*
Innovative atmosphere	258	9	30	4.29	4.25	High
Admisnistrative support	258	15	35	4.30	4.62	High

Organizational impediments	258	6	30	2.44	5.56	Moderate
Innovative School Scale	258	41	95	4.06	12.27	High
Teachers' openness to change	258	5	25	4.15	3.59	High
Principals openness to change	258	14	21	2.97	1.23	Moderate
School environment's press for change	258	6	15	4.18	2.02	High
Schools' Openness to Change Scale	258	38	59	3.65	5.08	Moderate
Managing unexpected situations	258	19	35	4.53	3.17	High
Interpersonal and cultural adaptability	258	21	25	4.88	1.04	High
Inability to cope with problems	258	6	21	1.61	3.09	Low
Adaptive Performance Scale	258	57	85	4.33	5.42	High

Table 3 shows that teachers' perceptions of innovative school ($\bar{X}$=4.06) and adaptive performance ($\bar{X}$=4.33) are at "high" level, while their perceptions of schools' openness to change ($\bar{X}$=3.65) are at "moderate" level. When the sub-dimensions of the innovative school scale are examined, teachers' perceptions of innovative atmosphere ($\bar{X}$=4.29) and administrative support ($\bar{X}$=4.30) are at "high" level, while their perceptions of organizational impediments ($\bar{X}$=2.44) are at " moderate" level. When the sub-dimensions of the schools' openness to change scale were analysed, the perceptions of the teachers on the school environment's press for change ($\bar{X}$=4.18) and teachers' openness to change ($\bar{X}$=4.15) were "high", while the perceptions of the teachers on the principals' openness to change ($\bar{X}$=2.97) were "moderate". When the sub-dimensions of the adaptive performance scale are analysed, teachers' perceptions of managing unexpected situations ($\bar{X}$=4.53) and interpersonal and cultural adaptability ($\bar{X}$=4.88) are at "high" level, while their perceptions of inability to cope with problems ($\bar{X}$=1.61) are at "low" level.

Correlation analysis was performed to determine whether there was a significant relationship between teachers' perceptions of innovative schools, schools' openness to change and adaptive performance. The results of the correlation analysis are presented in Table 4.

Table 4

Relationship between Teachers' Perceptions of Innovative Schools, Schools' Openness to Change, and Adaptive Performance

Scales	Innovative School Scale	Schools' Openness to Change Scale	Adaptive Performance Scale
Innovative School Scale	1		
Schools' Openness to Change Scale	.734**	1	
Adaptive Performance Scale	.551**	.588**	1

**p< .01

Table 4 shows that there is a positive and moderately significant relationship between teachers' perceptions of innovative schools and adaptive performance (r=.551, p<.01). There is a positive and moderately significant relationship between teachers' perceptions of adaptive performance and schools' openness to change (r=.588, p<.01). There is a positive and highly significant relationship between teachers' perceptions of innovative schools and schools' openness to change (r=.734, p<.01).

Hierarchical regression analysis was performed to determine whether teachers' perceptions of innovative schools and schools' openness to change are significant predictors of adaptive performance perceptions. The results of the hierarchical regression analysis are shown in Table 5.

Table 5

Predictiveness of Teachers' Perceptions of Innovative School and Schools' Openness to Change Perceptions of Adaptive Performance

Model	Variable (Analysis of adaptive performance scale)	*B*	$Standard\ Error_B$	*β*	*t*	*p*
1	Constant	66.933	2.707		24.722	.000*
	Innovative Atmosphere	.052	.122	.041	.424	.672
	Admisnistrative Support	.435	.116	.371	3.742	.000*
	Organizational Impediments	-.225	.059	-.231	-3.833	.000*
	R=.558 R^2=.312 $R^2\Delta$=.312 F(3,254)=38.366*** $F\Delta$(3,254)=38.366***					
2	Constant	57.316	5.668		10.111	.000*
	Innovative Atmosphere	-.102	.125	-.080	-.814	.416
	Admisnistrative Support	.232	.124	.198	1.861	.064
	Organizational Impediments	-.149	.058	-.153	-2.548	.011*
	Teachers' Openness to Change	.310	.118	.205	2.626	.009*
	Principals Openness to Change	.170	.230	.039	.742	.459
	School Environment's Press for Change	.727	.199	.272	3.648	.000*
	R=.624 R^2=.389 $R^2\Delta$=.077 F(6,251)=26.607*** $F\Delta$(3,251)=10.530***					

Model 1 in Table 5 shows that teachers' perceptions of innovative schools predicted their perceptions of adaptive performance significantly (R=.558, R^2=.312) (Fmodel 1(3-254)=38.366, p<.001). Teachers' perceptions of innovative school explained 31.2% of the variance of adaptive performance perceptions. Teachers' perceptions of *Administrative support* and *Organizational impediments* dimensions are

significant predictors of adaptive performance perceptions, while *Innovative atmosphere* dimension is not a significant predictor. The regression equation for Model 1 was determined as "*Adaptive performance*=66.933+.435*Administrative support*-.225*Organizational impediments*". A one-unit increase in teachers' perceptions of the dimension of *Administrative support* leads to a .435 (43.5%) unit increase in their adaptive performance. A one-unit increase in teachers' perceptions of *Organizational impediments* dimension leads to a .225 (22.5%) unit decrease in their adaptive performance. Accordingly, teachers' perceptions of *Administrative support* dimension affect their adaptive performance perceptions the most.

According to Model 2, teachers' perceptions of innovative school and schools' openness to change together predict their adaptive performance perceptions significantly (R=.624, R^2=.389) (Fmodel 2(6-251)=26.607, p<.001). Teachers' perceptions of innovative schools and schools' openness to change together explained 38.9% of the variance of adaptive performance perceptions. Moreover, when the possible effects of teachers' perceptions of innovative schools were controlled, teachers' perceptions of schools' openness to change predicted their perceptions of adaptive performance significantly ($R^2\Delta$= .077) ($F\Delta$ (3, 251)=10.530, p<.001). When the possible effects of teachers' perceptions of innovative schools were controlled, perceptions of schools' openness to change explained 7.7% of the variance of adaptive performance perceptions. According to Model 2, teachers' perceptions of *Organizational impediments, Teachers' openness to change* and *School environment's press for change* are significant predictors of adaptive performance perceptions. The regression equation for Model 2 was determined as "*Adaptive performance*=57.316-.149. *Organizational impediments+.310Teachers' openness to change+School environment's press for change*". One unit increase in teachers' perceptions of *Organizational impediments* dimension causes .149 (14.9%) unit decrease in teachers' perceptions of adaptive performance. One unit increase in teachers' perceptions of *Teachers' openness to change* dimension causes .310 (31%) unit increase in teachers' perceptions of adaptive performance. A one-unit increase in teachers' perceptions of *School environment's press for change* leads to a .727 (72.7%) unit increase in teachers' adaptive performance perceptions. Accordingly, while teachers' perceptions of *Innovative school and Schools' openness to change* are together, the perceptions of *School environment's press for change* affect their adaptive performance perceptions the most.

Discussion

Adaptability, which enables successful adaptation to changing conditions (Collie & Martin, 2016), is an important employee characteristic for organisations that adopt a flexible, efficient and innovative structure to ensure their continuity in global competitive conditions. This characteristic is considered within the scope of adaptive performance (Shoss et al., 2012). In this respect, adaptive performance emphasises the adaptability of employees to the changes occurring in the work environment (Park & Park, 2019). In this study, it was aimed to examine the effect of teachers' perceptions of innovative schools and schools' openness to change on their perceptions of adaptive performance. Firstly, the level of teachers' perceptions of innovative schools, schools' openness to change and adaptive performance were analysed. It was determined that teachers' perceptions of innovative schools were at a high level. This may indicate that

there is a high level of innovation in schools. It is imperative for schools to be innovative. This necessity stems from the fact that they assume the responsibility of raising individuals suitable for changing world conditions (Bodur & Argon, 2019). However, there are studies in the literature that determine that teachers' perceptions of innovative schools are at high level (Çayak & Erol, 2022) and moderate level (Akyürek, 2022; Bodur & Argon, 2019). On the other hand, it was determined that teachers' perceptions of the *Innovative atmosphere* and *Administrative support* dimension were high, while their perceptions of the *Organizational impediments* dimension were at a moderate level. This situation is also supported by Bodur and Argon (2019). Therefore, it can be stated that there is a high level of innovative atmosphere in schools and a high level of administrative support for innovations in schools, but there are some situations that prevent the realisation of innovations in schools.

Since schools are greatly affected by modernisation as a social system, schools should be open to change. In particular, school principals are expected to play important roles in how to initiate, implement and institutionalise change in the context of innovations in schools by emphasising that school principals are change agents. School principals should convince the employees that the change will be beneficial for them, produce solutions to the problems encountered in the change process and facilitate the change process (Meizatri et al., 2023). However, in this study, it was determined that teachers' perceptions of schools' openness to change were at a moderate level. Accordingly, it can be stated that schools are open to change but this is not enough. In the literature, there are different results regarding the openness of schools to change. Avşar et al. (2022) determined the openness of schools to change at low level, while Çağlar (2013, 2014) and Küçüksüleymanoğlu and Terzioğlu (2017) determined it at moderate level. On the other hand, in this study, teachers' perceptions of *School environment's press for change* and *Teachers' openness to change* were found to be high, and *Principals' openness to change* were found to be moderate. This may indicate that the environment of the schools creates a high level of change pressure on the schools and that the teachers perceive the changes positively at a high level, while the principals do not perceive the changes in the schools positively enough. However, Çağlar (2013, 2014) and Demirtaş (2012) found that principals' openness to change was higher than the change pressure of the school environment and teachers' openness to change. Küçüksüleymanoğlu and Terzioğlu (2017) found that the change pressure of the school environment was low and the openness of teachers and principals to change was at a moderate level. Canlı et al. (2015) found that school administrators were mostly prone to change.

Teachers have to adapt and modify their teaching to meet the diverse cultural, linguistic and instructional needs of their students (Vaughn et al., 2016). This has necessitated adaptability to be an important characteristic for teachers in the complex world of education. Teachers' adaptability is changing their practices in variable, new and uncertain situations (Loughland & Alonzo, 2019). Adaptive performance, on the other hand, refers to engaging in appropriate work behaviours in anticipation of or in response to changes that may occur in their tasks (Jundt et al., 2015). In this study, it was determined that teachers' perceptions of adaptive performance were at a high level. This may indicate that teachers adapt to the changing work environment and conditions at a high level. On the other hand, in this study, teachers' perceptions in the dimensions

of *Managing unexpected situations* and *Interpersonal and cultural adaptability* were found to be high, while their perceptions in the dimension of *Inability to cope with problems* were found to be low. Dilekçi and Sezgin-Nartgün (2020b) also reached similar results. This finding of the study may indicate that teachers have a high level of ability to cope with unexpected situations, manage crisis situations and cope with various problems in the work environment. It may also indicate that they have harmonious relationships with other people in the school and have a high level of sensitivity to different cultures.

In this study, it was determined that innovative schools significantly predicted teachers' adaptive performance. Innovative schools had a moderate effect on teachers' adaptive performance. As a matter of fact, the results of the correlation analysis also revealed that there was a positive and moderately significant relationship between innovative schools and teachers' adaptive performance. Accordingly, based on the results of both correlation and regression analyses, it can be said that teachers' adaptive performance increases as innovations are implemented in schools. However, only *Administrative support* and *Organizational impediments* dimensions were found to be significant predictors of teachers' adaptive performance. However, *Administrative support* dimension was a positive predictor and *Organizational impediments* dimension was a negative predictor. This shows that *Administrative support* causes an increase in teachers' adaptive performance, while *Organizational impediments* cause a decrease. Accordingly, it can be said that when administrative support is provided for innovations in schools, teachers' adaptive performance increases. However, when there are factors that prevent the realisation of innovations in schools, it can be stated that teachers' adaptive performance decreases. However, the *Administrative support* dimension had the most effect on teachers' adaptive performance. Similarly, Irawan and Sudibjo (2022) found that innovative work behaviour had a positive effect on employees' adaptive performance.

In this study, when the possible effects of innovative schools were controlled, schools' openness to change significantly predicted teachers' adaptive performance. This shows that when the possible effects of innovative schools are controlled, schools' openness to change affect teachers' adaptive performance. When the possible effects of innovative schools were controlled, schools' openness to change had a low effect on teachers' adaptive performance. Similarly, Visser (2012) determined that attitude towards change affects adaptive performance. Schulz (2010) determined that willingness to change affects adaptive performance. On the other hand, the results of the correlation analysis in this study revealed that there was a positive and moderately significant relationship between schools' openness to change and teachers' adaptive performance. Hashemi et al. (2019) also found a positive and moderate relationship between openness to change and adaptive performance. Schulz (2010) and Visser (2012) found a positive and moderate relationship between willingness to change and adaptive performance.

In this study, although the results of the correlation analysis showed a moderate relationship, the low effect in the regression analysis may be due to the control of the possible effects of innovative school perceptions. As a matter of fact, in this study, a positive and highly significant relationship was found in the correlation analysis results of the relationship between innovative schools and schools' openness to change.

Similarly, Çayak and Erol (2022) found a positive and highly significant relationship between teachers' perceptions of readiness for change and innovative schools. Due to this relationship, when the possible effects of innovative schools are controlled, schools' openness to change may have had a low impact on teachers' adaptive performance. However, based on the results of both correlation and regression analyses, it can be said that positive perceptions of changes in schools increase teachers' adaptive performance. The fact that the psychological readiness and behavioural intention supporting change indicated by openness to change can guide subsequent behaviours (Yue et al., 2019) may enable openness to change to be an indicator of teachers' adaptive performance.

In this study, innovative schools and schools' openness to change together significantly predicted teachers' adaptive performance. Accordingly, the realisation of innovations in schools and positive attitudes towards change in schools affect teachers' adaptive performance. Innovative schools and schools' openness to change moderately affected teachers' adaptive performance. While innovative schools and schools' openness to change together, *Organizational impediments, Teachers' openness to change* and *School environment's press for change* were significant predictors of teachers' adaptive performance. However, *Organizational impediments* were negative, *Teachers' openness to change* and *School environment's press for change* were positive predictors. This shows that *Organizational impediments* cause a decrease in teachers' adaptive performance, while *Teachers' openness to change* and *School environment's press for change* cause an increase. Accordingly, it can be stated that when there are factors that prevent the realisation of innovations in schools, teachers' adaptive performance decreases, while teachers' and school environment's positive acceptance of change increases teachers' adaptive performance. However, *School environment's press for change* dimension had the highest effect on teachers' adaptive performance. This may indicate the importance of school environment in shaping teachers' behaviours. It can be said that the change demands and expectations created by the school environment are more important than teachers' openness to change in increasing teachers' adaptive performance.

Conclusion and Recommendations

The results of this study showed that the school's openness to change affects adaptive performance when the possible effects of innovative school are controlled and innovative school affects administrative performance. However, it was determined that the innovative school and the school's openness to change together affect adaptive performance. The effect values revealed that these two variables together affect adaptive performance more. Accordingly, in order to increase teachers' adaptive performance, both innovative practices in schools and schools' openness to change should be increased. However, in this study, although it was determined that there is a high level of *Innovative atmosphere* in schools and a high level of *Administrative support* for innovations in schools, it was concluded that there are some situations that prevent the realisation of innovations in schools. Conducting qualitative studies to determine the factors that prevent the realisation of innovations in schools can contribute to the removal of these obstacles. On the other hand, the fact that teachers' perceptions of *Principals' openness to change* dimension in this study were at a moderate level may indicate that the principals did not meet the change in schools positively enough. In this

respect, qualitative studies can be conducted to reveal the factors that determine the factors that prevent principals' openness to change.

In this study, it was determined that organizational impediments caused a decrease in teachers' adaptive performance, while teachers' openness to change and the school environment's press for change caused an increase. Accordingly, it is important to eliminate the factors preventing the realisation of innovations in schools, to increase the openness of teachers to change and the school environment's press to change in order to increase the adaptive performance of teachers. School principals are recommended to eliminate the factors preventing the realisation of innovations and encourage innovations. Many individual and organisational factors affecting teachers' innovative behaviours have been investigated. The most frequently researched topic in organisational factors is leadership (Zainal & Matore, 2019). In this respect, school principals can increase innovation in schools through appropriate leadership behaviours. For example, principals' exhibiting change leadership can contribute to the realisation of innovations in schools by ensuring that school staff, especially teachers, are ready for change (Meizatri et al., 2023). In addition, school principals can contribute to the innovation of schools by exhibiting democratic leadership (Akyürek, 2022), supporting teachers and avoiding restrictive behaviours (Bodur & Argon, 2019). In addition, the Ministry of National Education can implement various practices in schools by determining policies to eliminate the factors that prevent the realisation of innovations in schools. For this purpose, the Ministry of National Education can initiate new practices in schools, give the necessary authority and budget support for new practices to be carried out in schools, and give various awards to teachers and administrators who carry out new projects to encourage innovation in schools.

Employees who are open to change and equipped are the greatest wealth of organisations (Tunçer, 2012). The school principal should be aware of this. With this awareness, firstly, he/she should be open to change. Then, he/she should see increasing the school's openness to change as a fundamental responsibility. In this context, school principals' acquisition of effective leadership qualities can increase teachers' openness to change (Cerit et al., 2018). The school principal's exhibiting transformational leadership and creating a compassionate communication in the school can positively affect employees' openness to change by increasing their organisational trust (Yue et al., 2019). School principals can increase openness to change by involving school stakeholders in the change process, providing information about change and its consequences, making them feel the need for change, and increasing their self-efficacy to cope with change (Lenberg et al., 2017; Wanberg & Banas, 2000). In addition, employees' not believing in the benefits of change and their fears that they may be harmed by change are the reasons for resistance to change (Helvacı, 2011). In order for employees to adopt change and to be encouraged when necessary, ensuring that they believe that change will be beneficial for the organisation and themselves (Töremen, 2002) can increase openness to change.

This study has made important contributions in terms of revealing the contextual factors affecting teachers' adaptive performance. In addition, it has made important contributions on how the contexts of innovative schools and schools' openness to change can be used to increase teachers' adaptive performance. However, this research has some limitations. This research is limited to the responses of the teachers in the

sample to the data collection tools. Similar research can be conducted with different samples and data collection tools. In this study, it was not determined how the innovative school would affect adaptive performance when the possible effects of schools' openness to change were controlled. The role of innovative school as a mediating variable in the relationship between schools' openness to change and adaptive performance was not determined. These situations can be analysed in future studies. On the other hand, the influence of these three variables on each other can be analysed from different aspects. Studies examining the mediating effect of one of the variables between these three variables can be conducted. With such studies, it can be contributed to reveal the relationships between the three variables more clearly.

Statement of Responsibility

Corresponding author is responsible for literature review, methodology, data collection, data analysis, resources, writing-original draft. Author 2 is responsible for investigation, literature review, writing-review& editing, supervision.

Conflicts of Interest

There is no conflict of interest between authors.

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The Effect of Using Technology-Assisted Drama Method in Teaching the Central Nervous System Subject on Academic Achievement and Attitude

Merkezi Sinir Sistemi Konusunun Öğretiminde Teknoloji Destekli Drama Yöntemi Kullanılmasının Akademik Başarı ve Tutum Üzerine Etkisi

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ABSTRACT: The aim of this research is to examine the effects of technology-supported drama method applications on students' academic achievements regarding the central nervous system and their attitudes towards biology. In the research, quasi-experimental design with pre-test post-test control group, one of the quantitative research methods, was used. The sample of the research consists of 50 students studying in two separate classes at a state university and taking biology courses. Within the scope of the research, the subject of the central nervous system was taught with the traditional teaching method in the control group and with the technology-supported drama method in the experimental group. In the research, "Academic Achievement Test" and "Biology Attitude Scale" were used as data collection tools to measure the academic achievements of the students. A statistical package program was used to analyze the data. As a result of the research, it was determined that the course carried out with the technology-supported drama method generally positively affected the academic achievements and attitudes of the students. In future studies, it is recommended that the effects of technology-supported drama method on students' academic achievement and attitudes in biology courses be examined in the long term with larger and more diverse sample groups.

Keywords: Drama, technology supported education, biology education, academic achievement, attitude.

ÖZ: Bu araştırmanın amacı, teknoloji destekli drama yöntemi uygulamalarının öğrencilerin merkezi sinir sistemi konusuna ilişkin akademik başarılarına ve biyolojiye yönelik tutumlarına etkisini incelemektir. Araştırmada nicel araştırma yöntemlerinden ön-test son-test kontrol gruplu yarı deneysel desen kullanılmıştır. Araştırmanın örneklemini bir devlet üniversitesinde iki ayrı sınıfta öğrenim gören ve biyoloji dersi alan 50 öğrenci oluşturmaktadır. Araştırma kapsamında merkezi sinir sistemi konusu kontrol grubunda geleneksel öğretim yöntemiyle, deney grubunda ise teknoloji destekli drama yöntemi ile işlenmiştir Araştırmada veri toplama aracı olarak öğrencilerin akademik başarılarını ölçmek amacıyla, "Akademik Başarı Testi" ve "Biyoloji Tutum Ölçeği" kullanılmıştır. Verilerin analizinde bir istatistik paket programı kullanılmıştır. Araştırma sonucunda teknoloji destekli drama yöntemi ile gerçekleştirilen dersin, genel olarak öğrencilerin akademik başarılarını ve tutumlarını olumlu yönde etkilediği tespit edilmiştir. Gelecek araştırmalarda teknoloji destekli drama yönteminin öğrencilerin biyoloji derslerindeki akademik başarılarına ve tutumlarına etkisinin daha geniş ve daha çeşitli örneklem grupları ile uzun vadede incelenmesi önerilmektedir.

Anahtar kelimeler: Drama, teknoloji destekli eğitim, biyoloji eğitimi, akademik başarı, tutum.

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Biology education aims to give people the ability to recognize the individual, the environment, society, the development of society, the health of individuals and environmental health. Every individual should receive biology education, even at a basic level (Özkan, 2011). However, since biology contains many foreign terms, words of Latin origin and complex relationships, it becomes more challenging to teach and learn compared to other disciplines. For this reason, one of the most frequently used methods in biology learning is the memorization method. However, this method prevents students from establishing connections between concepts and makes it difficult for them to succeed when they face questions that require analysis, synthesis and evaluation (Köse, 2008).

The progress of a society is closely related to the qualities that the education system creates in individuals. Therefore, the education system should be carefully planned to make individuals thinking, questioning, able to produce innovative solutions to problems, creative and effective (Kılıç & Sağlam, 2004). Today, biology education is constantly being renewed with the advances in educational sciences and technology. Rather than basing biology education on memorized information, teaching methods that will enable students to develop in-depth understanding and the ability to compare and interpret biology subjects are being focused on (Aşılıoğlu & Aytaç, 2002). One of the methods that can develop these skills is creative drama. Many evidences that creative drama contributes to learning are frequently encountered in the literature (Çetinkaya Aydoğdu & Kirpik, 2021; Kırmızı Susar, 2007; Koç & Geçit, 2021; Öztürk & Korkmaz, 2020).

Creative drama is a workshop that focuses on the successful achievement of specified goals, is carried out with a group accompanied by a leader and includes the steps of "Warm-up, Revitalization and Evaluation", and has no age or subject restrictions (Akdemir & Karakuş, 2016). Creative drama is a method that can be used at all levels of education, starting from pre-school education, including university and graduate education, and can be applied in various fields (Akgül, 2018; Köksal Akyol, 2003). This method offers students the chance to act out a situation or event and assume the roles of the relevant characters. Students are given background information about the characters they will portray and then asked to express their perspectives by putting themselves in the shoes of these characters or empathizing with them (Stradling, 2003, p.107, as cited in Altıkulaç & Akhan, 2010). In the process of drama in education, the individual experiences and learns how to communicate in almost every moment of daily life in sample events and situations. In the course taught with drama method, students can develop their speaking, listening, reading comprehension and written communication skills while taking different roles and expressing their feelings, thoughts and wishes through improvisation (Maden & Dinç, 2017). Different concepts that mean drama, such as drama and creative drama, are used in education. In addition, it is noteworthy that concepts such as role playing and improvisation are used instead of drama. However, role playing are techniques involved in the improvisational drama process. The concept of drama is expressed in a wide range as different terms are used in different countries and educational approaches. For example, while it is called "creative drama" in the United States, the term "drama in education" is more common in England and "creative drama" is more common in Turkey. As Çifci and Altınova (2012) state, the general purpose of creative drama is to raise individuals who are

creative in every field, self-sufficient, self-aware, able to communicate with their environment and improve this, and with increased expression power and forms.

Biology course, by its nature, includes subjects suitable for role-playing. For this reason, it can be ensured that students move away from abstract concepts by acting out the events and the lesson becomes more interesting. Compared to other teaching methods, creative drama method is student-centered and encourages active participation, thus creating an interactive social learning environment. Biology course is one of the areas where creative drama method can be used effectively since it is an important course where students take their first steps towards science and technology (Aydın & Bülbül, 2011).

In addition to the creative drama method, another method that has a significant impact on the learning process is technology-assisted instruction. In today's rapidly changing world, educators are now realizing the importance of students learning not only the information they memorize, but also how to creatively develop and use this information in practice. New technologies hold great promise for overcoming traditional barriers to professional development (Wiske et al., 2001). Today, many technologically advanced countries have realized that the real power is no longer physical, but in the educated human brain. At every stage of education, many technologies are used, from blackboards to books, from projectors to computers (Çetin et al., 2004). Advances in technology enable technological tools to be used more widely and spread rapidly in the field of education (Karadüz & Baytak, 2010). The use of technology in educational environments increases the quality of the educational process. This use reduces educational costs, facilitates adaptation to developing technology, and provides students with the knowledge and skills they need in their individual and social lives (Tiryaki & Demir, 2020). Use of technology-supported instruction in lessons positively affects students' interest and learning (Ünal & Yeşilyurt, 2023).

Although there are many studies in the literature on the effectiveness of technology-supported instruction and creative drama methods in different disciplines (Kolovou & Kim, 2020; Shim et al., 2003; Tsaushu et al., 2012; Yağmur, 2010; Yalım, 2003; Yılmaz et al., 2023), the number of applications in which these methods are used together is quite limited (Anderson et al., 2016; Dimililer et al., 2017; Gürbüz & İlgaz, 2021; Öztürk & Korkmaz, 2020; Yağmur, 2010). When the problem is examined in terms of the effectiveness of technology-supported drama method in biology course, there is no research on the effectiveness of technology-supported drama method in biology course.

In addition, considering the aforementioned researches, in learning environments where technology-supported drama method is applied, students are not limited to memorizing the course; they can also become aware of how they learn (Öztürk & Korkmaz, 2020)

Therefore, technology-supported drama method can provide students with a more effective learning experience in the biology course and encourage them to actively assimilate information instead of passively taking it.

In this context, it is predicted that this research will make an important contribution by filling the gaps in the literature. In this context, the aim of the research is to investigate the effects of using technology-supported drama method on students'

academic achievement and attitude towards the central nervous system in biology course.

In this direction, the sub-problems of the research are as follows;

1. Is there a statistically significant difference between the experimental group and the control group in terms of academic achievement in terms of pre-test scores before the experimental study?
2. Is there a statistically significant difference between the experimental group and the control group in terms of pre-test attitude scores before the experimental study?
3. Is there a statistically significant difference between the experimental group in which Technology Supported Drama Method was applied and the control group in which traditional teaching method was applied in terms of academic achievement in terms of post test scores?
4. Is there a statistically significant difference between the experimental group in which Technology Supported Drama Method was applied and the control group in which traditional teaching method was applied in terms of post-test attitude scores?

Method

Research Design

In this research, a quasi-experimental design with pre-test post-test control group was used among quantitative research methods. Quasi-experimental design is a type of experimental design generally used in educational research. This design is used when it is not possible for researchers to conduct real experiments and control all variables. It especially covers situations where different conditions are examined in existing groups and individuals in schools or classes cannot be randomly selected (Cohen et al., 2000). This design aims to test how different the change in one of the groups is from the change in the other group (Büyüköztürk, 2007). The pretest-posttest control group design is a design in which participants are evaluated both before and after the experimental study with a measurement related to the dependent variable. Participants are divided into two groups as experimental group and control group (Karasar, 2005). The experimental design used in the research is shown in Table 1.

Table 1

Experimental Design Used in the Research

Working group	Pre-test	Application	Post-test
Experimental group (EG)	Academic achievement test, biology attitude scale	Technology supported drama method	Academic achievement test, biology attitude scale
Control group (CG)	Academic achievement test, biology attitude scale	Traditional classroom method	Academic achievement test, biology attitude scale

Participants

The sample of the research consisted of a total of 50 students studying in two seperate classes and taking biology course at a state university. One of the classes was accepted as the experimental group and the other as the control group. Analyses were conducted on the total data of these two classes. Since the number of classes taking biology course in the research was limited and only one instructor allowed the application in his/her course, convenience sampling method, one of the non-random sampling methods, was used in sample selection. In this context, a total of two classes were determined. In quasi-experimental studies, since the researcher cannot create groups artificially, such studies involve the unbiased selection of groups. The researcher objectively selects one of the existing groups as the experimental group and uses the other as the control group (Creswell, 2005, cited in Erdoğan & Şengül, 2017).One of the classes was selected as the experimental group in which the Technology Supported Drama Method was applied; the other was selected as the control group in which the traditional classroom method was applied as specified in the curriculum. The gender distribution of the participants in the research is shown in Table 2.

Table 2

Distribution of Participants by Gender

Gender	Experimental group	Control group
Male	15	14
Female	10	11

Data Collection Tools

In the research, 2 scales were used as data collection tools.

For academic achievement: In the research, “Academic Achievement Test” developed by Akman (2023) was used to measure the academic achievement of the students. The scale consists of a total of 19 items including multiple-choice questions to determine students’ academic achievement on the central nervous system. The KR20 value of the academic achievement test was calculated as .81.

For attitude Biology Attitude Scale, which was developed by Geban et al. (1994) to determine students’ attitudes towards chemistry and modified by Pekel (2005) as biology attitude scale, was used in the research. The scale was prepared in 5-point Likert type and consisted of 15 items in total. The Cronbach’s alpha reliability coefficient of the entire Biology Attitude Scale was .926.

Data Analysis

A statistics package program was used to analyze the data obtained at this stage. The Kolmogorov-Smirnov test was applied for the academic achievement test and attitude scale in order to evaluate the suitability of the data obtained from the research for normal distribution and the kurtosis-skewness coefficients were examined and it was determined that normality was achieved. In addition, the kurtosis and skewness values of the data were examined and it was tested whether these values were between +1.5 and -1.5 (Tabachnick & Fidell, 2013).As the achievement test and attitude scale data

showed normal distribution in the experimental and control groups, parametric test was used. Arithmetic mean, standard deviation and independent sample t test were used to compare students' academic achievement and attitude scores towards biology course.

Implementation Process

A pretest was administered to the experimental and control groups to determine their level of knowledge about the central nervous system. Both groups were allocated 6-hour lessons separately and a total of 3 weeks for the explanation of the central nervous system. The pretest and posttest applications were excluded from these 3 weeks. Before starting the drama practices, in the first week, detailed information about the technology-supported drama method was presented to the students, and the roles of the students in the process of dramatizing the central nervous system were determined by distributing the roles. In the second week, during the implementation phase, all students in the class participated effectively in the drama activities, the students both processed the subject with creative drama technique and an interactive learning environment was created by utilizing technological tools. It was ensured that students used technological tools effectively in drama practices. Various technological tools such as projectors, tablet computers, CDs, voice recorders and stethoscopes were introduced to the students. These tools were used to dramatize the topic of the central nervous system and to help students determine their roles. Students shared visual materials with projectors, accessed interactive content with tablet computers, provided effective voice-over with voice recorders, and made dramatized situations more realistic with stethoscopes. In this way, technology enriched the learning experience by enabling students to actively and effectively participate in drama activities. Students covered the course topic with a combination of creative drama technique and technological tools. In the last week, the students were divided into groups and evaluated the applied method and discussed the parts of the Central Nervous System.

Prepared creative drama plans should be examined by at least one expert before implementation and any deficiencies should be corrected (Yağmur, 2010). The drama activity implemented in the course was examined and approved by two experts in the field of biology education and creative drama. In this process, first of all, expert opinions were received and ideas were shared about drama activities that could be used in biology course content. Experts have determined which topics are suitable for drama activities, how student participation can be ensured, and how the activities can be evaluated. Then, the central nervous system topic was chosen in line with expert opinions and consensus of researchers. Drama activity was created by researchers. Experts examined and revised the deficiencies and faulty parts of the creative drama activity and suggested arrangements. In line with these suggestions, the activity was finalized and implemented. The drama activity prepared for the central nervous system subject is as follows;

> Mrs. Hatice sits and watches television. Her son Selçuk comes in, takes the remote control and changes the channel. To his mother:
>
> Selçuk: what did you cook?
>
> Mrs. Hatice: Leek meal.
>
> Selçuk: What a leek! I don't like leeks. Make me another meal!

Mrs. Hatice: I wish you would get married as soon as possible!

Mrs. Hatice talks to herself internally:

Mrs. Hatice: I urgently need to get my son married. I wonder who I should find to marry him off. Hanife's daughter is very beautiful, she is very hardworking. Let me tell her to my son.

Mrs. Hatice: I went to Hanife's house the other day and her daughter has grown so big and beautiful. And she's so hardworking.

Selçuk understands his mother's intentions:

Selçuk: I understand your intentions, but don't tire yourself. I won't marry the girl you found. What age are we living in?

Selçuk leaves the room complaining:

Mrs. Hatice: I need to marry my son urgently. Let his wife suffer a little bit, I have suffered until this age.

Brain: *(the previously recorded voice comes on the computer as an external voice):* Okay, let's say you got your son married, but what about the wedding expenses, there is the gold, the engagement, the henna, the wedding.

Mrs. Hatice: You thought very right, brain, but what about these expenses?

Brain: In my opinion, the shortest thing to do is to have a family engagement and then a wedding. *(Computer recording as an external voice)*

Mrs. Hatice: Will the girl and her family accept this?? Enough is enough, I'm getting sick thinking about it *(Mrs. Hatice faints and is taken to the hospital by the people around her). (Mrs. When Hatice wakes up, she is in the hospital).*

Doctor: Hello Mrs. Hatice, you scared us but you are fine, right?

Mrs. Hatice: Well, doctor, there are endless noises in my brain.

Doctor: Hmm. Well, if you want, let's examine your organs. Let's even look at them and talk to your brain and other organs that make up your central nervous system *(first the tablet and then the computer is used)*

Yes, doctor.

Doctor: Yes, we are now seeing the brain, cerebellum, spinal cord and spinal bulb. *(Everyone tries to speak at the same time, buzzing). (Brain raises his voice)*:

Brain: Hey can everyone be quiet? I'm telling you, listen to me! I am your center, remember that.

Cerebellum: So what if you are our center. Without me you would be off balance, remember that I am the BALANCE! Without me, your arms and legs would be out of balance *(laughs).*

Brain: Okay, you are the center of balance, but I am the MANAGER! I am the manager; you are all employees *(laughs).* Learning, memory, hunger, thirst, sleep, wakefulness, blood pressure, body temperature, speech, writing, senses, hormones. oooo you see I have it all.

(Spinal cord interjects)

Spinal cord: You're making a big fuss! I also provide the connection between the organs and the central nervous system. So only you have important tasks? Reflexes occur under my control (e.g., pupil dilates or shrinks according to the intensity of the light (role-play), the foot lifts up when the kneecap is tapped (role-play). Pulling the hand away when touching a hot object (simulated). The sucking movement of a newborn baby. Also, without me, there would be no learned reflexes. You would not be able to ride a bicycle, swim or knit. Look how everyone's mouth is watering when they see this lemon *(shows lemons to those sitting).*

(The spinal bulb can't take it anymore)

Spinal bulb: Please calm down. We all have important tasks. For example, I control the internal organs. This is how the digestive, respiratory, excretory and circulatory systems work properly. Swallowing, chewing, coughing (cough sound), sneezing (sneeze sound), vomiting (grimace) is also under my control. Also remember that I am an intermediary. The neural transmission between the spinal cord and the brain is mediated by me. We are a team, remember.

And why are we at odds with each other like this? Obviously, there is a problem.

Brain: Yes. Mrs. Hatice gets stressed about her son, so of course we have the right to respond. And when she gets overwhelmed with thoughts, we fall out with each other like this. Could you take this CD? *(Hands a CD to the doctor).* If it were up to us, this bet would not end until the morning. The best thing is for you to watch and see what we do. Oh, and please don't stress yourself and put us in this situation. Ahh Ahh, I want to see this world before I die. I'm asking for too much! *(CD is opened and a video about the central nervous system is shown)*

Doctor: Yes Mrs. Hatice, your central nervous system organs are very troubled. We should find solutions to the problems without stressing ourselves so that our organs are not damaged.

Figure 1

Central Nervous System Technology-Supported Drama Activity

The lessons in the control group were taught with traditional teaching methods. Within the framework of this method, the teacher explained the lessons and presented them with direct explanation and question-answer techniques. Lessons were held on time and with the active participation of the teacher, previous lessons were repeated at the beginning of each lesson, and questions were asked to the students to get feedback at the end of each lesson. After the interventions, a post-test was administered to the experimental and control groups to assess their level of knowledge about the central nervous system.

Ethical Procedures

The legal obligation to comply with ethical rules has been approved by the decision of Kafkas University Social and Human Sciences Scientific Research and Publication Ethics Board dated 24.11.2023 and numbered 29.

Results

In this section, the data obtained from the research on each sub-problem are tabulated and presented.

Findings Related to the First Sub-Problem

Before the application, independent samples t test was applied to determine whether there was a difference between the academic achievement of the students in the experimental and control groups on the central nervous system. The results of the analysis of the pretest scores of the experimental and control groups are presented in Table 3.

Table 3

Mean, Standard Deviation and T-Test Results of the Pretest Scores of the Experimental and Control Groups

Groups	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Experimental group	25	40.41	12.03	48	.256	.799
Control group	25	39.55	11.78			

*$p>.05$

According to Table 3, the mean score of the experimental group ($\bar{X}$=40.41) and the mean score of the control group ($\bar{X}$=39.55) were close to each other. According to the results of the independent samples t-test analysis, there is no statistically significant difference between the experimental and control groups [$t(48)=.256$, $p>.05$]. Therefore, it can be said that there is equivalence between both groups in terms of academic achievement.

Findings Related to the Second Sub-Problem

In order to determine the effect of Technology Supported Drama Method applications on academic achievement, independent samples t test was applied to determine whether there was a difference between the experimental and control groups. The results of the analysis of the post-test scores of the experimental and control groups are presented in Table 4.

Table 4

Mean, Standard Deviation and T-Test Results for the Academic Achievement Post-Test Scores of The Experimental and Control Groups

Groups	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Experimental group	25	66.73	11.54	48	2.557	.014
Control group	25	57.04	15.01			

*$p<.05$

When Table 4 is examined, it is observed that the mean score of the experimental group ($\bar{X}$=66.73) is higher than the mean score of the control group ($\bar{X}$=57.04). According to the results of the independent sample t-test, there is a statistically significant difference between the experimental and control groups in terms of academic achievement posttest scores [$t(48)=2.557$, $p<.05$]. These findings show that the experimental group has a higher performance than the control group.

Findings Related to the Third Sub-Problem

Before the application, an independent samples t-test was applied to determine whether there was a difference between the attitudes of the students in the experimental and control groups towards biology. The results of the analysis of the pretest scores of the experimental and control groups are presented in Table 5.

Table 5

Mean, Standard Deviation and T-Test Results According to the Attitude Scale Pre-Test Scores of The Experimental and Control Groups

Groups	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Experimental group	25	3.06	.58070	48	-.706	.484
Control group	25	3.07	.48338			

*$p>.05$

According to Table 5, the mean score of the experimental group ($\bar{X}$=3.06) and the mean score of the control group ($\bar{X}$=3.07) for attitude towards biology were close to each other. According to the results of the independent samples t-test analysis, there was no statistically significant difference between the experimental and control groups [$t(48)=-.706$, $p>.05$]. Therefore, it can be said that there is equivalence between the experimental and control groups in terms of attitude.

Findings Related to the Fourth Sub-Problem

In order to determine whether there is a difference between the experimental and control groups in order to determine the attitude of Technology Supported Drama Method applications towards biology course, independent samples t test was applied. The results of the analysis of the post-test scores of the experimental and control groups are presented in Table 6.

Table 6

Mean, Standard Deviation and T-Test Results According to the Attitude Scale Post-Test Scores of The Experimental and Control Groups

Groups	*n*	$\bar{X}$	*ss*	*sd*	*t*	*p*
Experimental group	25	3.44	.40070	39.089	2.143	.038
Control group	25	3.11	.67377			

*$p<.05$

When Table 6 is examined, it is observed that the mean score of the experimental group ($\bar{X}$=3.44) is higher than the mean score of the control group ($\bar{X}$=3.11). According to the independent sample t-test results, there is a statistically significant difference between the experimental and control groups in terms of attitude post-test scores [t(39,089)=2.143, p<.05].These findings reveal that the experimental group has a higher attitude than the control group.

Discussion and Conclusion

In this research, it was aimed to determine the effect of technology-supported drama method applications on students' academic achievement related to the central nervous system and attitude towards biology. When the literature is examined, there are studies on the contribution of drama to biology education (Abrahams & Braund, 2012; Aydın & Bülbül, 2011; De Beer et al., 2018). Similarly, there are studies on the contribution of technology-supported instruction to biology education (Taşçı et al., 2010; Van Rooy, 2012; Yang et al., 2015). However, there is no research in which both drama and technology-supported instruction are used together in biology course. One of the main reasons why students fail in science courses is that the subjects are abstract and complex and the curricula present these subjects in an abstract (Doğan et al., 2004). Biology courses are generally perceived by students as a course that requires memorization and therefore are not given enough importance (Özatlı & Bahar, 2010). In learning environments where drama and technology-supported teaching are applied, students can have the opportunity to understand what and how they learn more deeply instead of just memorizing the Biology course. These approaches offer a significant potential to provide students with meaningful learning experiences and enable them to comprehend information more effectively.

As a result of the analysis, no statistically significant difference was observed between the experimental group and the control group in terms of pre-test academic achievement before the experimental study. This result shows that the students' initial knowledge about the central nervous system is at a similar level. However, when the post-test scores were examined, it was determined that there was a significant difference between the post-test academic achievement scores of the experimental group and control group students participating in the research in favor of the experimental group. This finding points to the effectiveness of the course taught with the technology-supported drama method. This finding, which emphasizes the effectiveness of the course in which technology-supported drama method is applied, is similar to the results of a small number of studies in the existing literature (Anderson et al., 2016; Dimililer et al., 2017; Gürbüz & İlgaz, 2021; Öztürk & Korkmaz, 2020; Yağmur, 2010). Therefore, this result obtained from the current research is consistent with the results of previous studies and strongly supports the potential of technology-supported drama method to increase student achievement. In addition, many studies have been conducted on the effect of drama method and technology-supported instruction on student achievement. The general results of these studies conducted at different levels reveal that both methods positively affect students' achievement levels (Akgül, 2018; Akgün et al., 2014; Campbell, 2013; Kaf & Yilmaz, 2017; Karadüz & Baytak, 2010; Kavan, 2021; Maden & Dinç, 2017; Yağmur, 2010; Yalım, 2003; Yılmaz et al., 2023).

Another result obtained from the research shows that the application of technology-supported drama method positively affects students' attitudes towards the course. If the methods and techniques used in the course are varied and create an interesting structure for students, this may contribute to the development of positive attitudes towards the course (Öztürk & Korkmaz, 2020). Therefore, it can be said that the reason for this situation is that teaching the lesson with this method provides students with a fun experience and they have a pleasant time in the lesson. In support of this situation, Öztürk and Korkmaz (2020) stated in their research that social studies teaching with technology-supported creative drama activities made a greater contribution to students' attitudes and problem-solving skills compared to traditional methods. In addition, there are many studies on the effects of drama approach associated with technology-supported drama method and technology-supported teaching on attitudes. For example; Ong et al. (2020) concluded that creative drama was effective on science students' career interests and attitudes towards science. Campbell (2013) stated in his research that drama supports motivation, self-efficacy and attitudes. In their research, Zengin and Ulaş (2021) stated that teaching social studies course with drama activities was effective on students' attitudes. Akkale and Özalp (2023) stated in their research that classroom teachers have a very high level of attitude towards the use of creative drama method. Yılmaz (2005) examined the effect of the use of technology in education on student achievement and attitude and found that technological tools had a positive effect on achievement and attitude. Yavuz and Coşkun (2008) examined the attitudes of classroom teaching students towards educational technologies and technological tools and the results of the attitude scale revealed a positive development in students' attitudes towards technology.

In conclusion, a general overview of the results of the research shows that the course conducted with the technology-supported drama method generally increased the academic achievement and attitudes of the students positively.

Technology-supported drama activities encouraged students' active participation and provided them with the opportunity to develop their ability to reconcile abstract concepts with concrete experiences and to understand them in depth. Students learned basic concepts about the central nervous system thanks to technology-supported drama activities.

The recommendations developed based on the research results are as follows:

- In order to evaluate the effect of the technology-supported drama method on biology subjects, studies with larger, more diverse sample groups and longer periods of time can be conducted, so that a more comprehensive understanding of the effect of the method on students' attitudes and academic success levels can be possible.
- In this research, the effects of technology-supported drama method applications on students' academic achievements and attitudes towards biology on the central nervous system were examined. In future studies, variables such as motivation and problem solving can be examined in relation to this issue.
- Similar applications can be made in different subjects that are thought to be difficult for students in the biology course.

- By using different teaching methods, the effects of the methods used can be evaluated.
- Educators can increase the effectiveness of the method by constantly conducting research and development studies on the technology-supported drama method.
- Educators can use the technology-supported drama method not only in biology classes but also by integrating it with other disciplines.
- Educators can provide students with collaborative learning environments by using the technology-supported drama method. Group projects and teamwork allow students to learn by working together and develop social skills.

Statement of Responsibility

All parts of the article were co-written by the authors. All sections such as Introduction, Method, Results, comment, discussion, and conclusion were written together. All expenses related to the article were made by the authors.

Conflicts of Interest

The authors have no competing interests to declare that are relevant to the content of this article.

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Conceptualizing Pre-Service Mathematics Teachers' Approaches towards Responding to Availability of Tools and Resources in the Context of Knowledge Quartet*

Matematik Öğretmeni Adaylarının Araç ve Kaynakların Erişilebilirliğine Yanıt Vermeye Yönelik Yaklaşımlarının Dörtlü Bilgi Modeli Bağlamında Kavramsallaştırılması

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ABSTRACT: The purpose of this study is to conceptualize the approaches of secondary mathematics pre-service teachers towards contingencies encountered during the teaching process within the context of responding to availability of tools and resources. In order to achieve the goal of the study based on the grounded theory, the nine secondary mathematics pre-service teachers' lessons were observed, and recorded using a video camera, and semi-structured interviews were performed. The data collection process ended after 54 lesson hours of observation, that is, when code saturation was reached. As a result, four sub-codes in the context of responding to availability of tools and resources were identified within the approaches of participants in relation to contingent moments. It is thought that conceptualizing the approaches of participants towards unplanned situations encountered during lessons in real class environment would prove to be beneficial in teacher training.

Keywords: Contingency, grounded theory, knowledge quartet, pre-service mathematics teachers, responding to availability of tools and resources.

ÖZ: Bu çalışmanın amacı, matematik öğretmeni adaylarının öğretim sürecinde karşılaştıkları beklenmeyen olaylara yönelik yaklaşımlarını, araç ve kaynakların erişilebilirliğine yanıt verme bağlamında kavramsallaştırmaktır. Araştırmanın katılımcıları dokuz matematik öğretmeni adayıdır. Gömülü teoriye dayalı çalışmanın amacına ulaşabilmesi için katılımcıların dersleri gözlemlenmiş, video kamera kullanılarak kayıt altına alınmış ve öğretmen adayları ile yarı-yapılandırılmış görüşmeler yapılmıştır. Kod doygunluğuna ulaşıldığında veri toplama işlemi tamamlanmıştır. Böylece katılımcılar tarafından yürütülen toplam 54 saatlik ders incelenmiştir. Sonuç olarak katılımcıların beklenmeyen olaylara ilişkin yaklaşımları içerisinde araç ve kaynakların erişilebilirliğine yanıt verme bağlamında dört alt kod belirlenmiştir. Katılımcıların gerçek sınıf ortamındaki derslerinde ortaya çıkan önceden planlanmamış durumlara ilişkin yaklaşımlarının kavramsallaştırılmasının öğretmen eğitiminde yarar sağlayacağı düşünülmektedir.

Anahtar kelimeler: Beklenmeyen olaylar bilgisi, gömülü teori, dörtlü bilgi modeli, matematik öğretmeni adayı, araçların ve kaynakların erişilebilirliğine yanıt verme.

*This paper is made up of an improved version of the doctoral thesis titled "Conceptualizing Mathematics Pre-Service Teachers' Approaches Towards Contingency in Teaching Process in The Context of Knowledge Quartet", which was carried out by the first author under the supervision of the second author.

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Pedagogical Content Knowledge (PCK) is one of the seven knowledge bases that teachers should have (Shulman, 1987). According to Shulman, PCK relies mostly on a teacher's capacity to transform the subject matter knowledge into other forms which can enable students to understand the subject. Examining the studies regarding PCK shows that several frameworks have been presented (Bukova-Güzel, 2010). One of these frameworks is the "Knowledge Quartet (KQ)" which allows mathematics pre-service teachers to be evaluated and developed during their instruction (Rowland et al., 2009). The KQ centers on teachers' observable mathematics-related knowledge as it manifests in situations within the mathematics classroom (Carlsen et al., 2023).

Knowledge Quartet is constituted of four units named foundation, transformation, connection, and contingency, and the codes of these units (Rowland et al., 2005). Foundation deal with beliefs and propositional knowledge related to mathematics and mathematics pedagogy (Rowland, 2005). Transformation involves choosing examples and procedures that help create concepts, making demonstrations that require the teacher to transform his or her own knowledge so that learners can understand it better (Turner, 2005). Connection refers to the teacher's ability to sequence the content and associating the content between mathematics and other subject areas (Fitzmaurice et al., 2021). Contingency, the unit in the focus of the research, deals with situations that cannot be planned before the lesson (Rowland et al., 2009; Thwaites et al., 2005; Turner, 2005). The idea that while most situations in the classroom can be planned, some cannot, prompted the researchers to generate this unit (Rowland et al., 2009). For this reason, contingency refers to the knowledge that a teacher employs in order to address unexpected strategies, questions, or comments from learners (Kgothego & Westaway, 2023). Contingency also covers how teachers respond to unplanned instances in a lesson, which often tests their ability to "think on their feet" (Mutlu & Duatepe Paksu, 2022; Petrou, 2010; Rowland et al., 2005).

Rowland et al. (2011) suggested that the consideration of contingency including its possible triggers and reasons of such triggers had an important but, yet unrecognized, place in mathematics teacher education. Mathematics teachers may not predict contingent moments before they happen as well as pre-service teachers. Contingency consists of four codes named as deviation from lesson agenda, teacher insight, responding to students' ideas, and responding to the (un)availability of tools and resources (Thwaites et al., 2011). In the study we focused on responding to the (un)availability of tools and resources.

Responding to the (Un)Availability of Tools and Resources

The code of responding to the (un)availability of tools and resources is related to the tools and resources teachers use to concretize, in particular, abstract concepts (Rowland et al., 2015). Such tools, resources and materials may be the main tool of the lesson plan, or they may be included in the lesson as an opportunity although they were not in the plan initially (Rowland et al., 2011). Cohen et al. (2003) stated that accessing more resources for teaching does not cause learning. The teacher can benefit from the tools and resources available in the classroom or that come to mind during the lesson by integrating these materials into the lesson, even if they are not included in the lesson plan.In fact, this unexpected availability of a resource prompted a change in pedagogical strategy (Thwaites et al., 2011). The teacher's ability is important in the use of tools and

resources for effective teaching. Researchers report that schools and teachers with the same resources do different things, with results for learning because of the uses of resources (Cohen et al., 2003).

Educational resources, conventionally conceived, refer to money or the things that money buys, including books, buildings, libraries, teachers' formal qualifications, and more (Cohen et al., 2003). The tools and resources that teachers can make use of during the lesson can be either analog or digital (Rowland et al., 2015). For example, the teacher can add a software specific to algebra-geometry to the lecturing, as well as add a material such as a hundred chart that crosses his or her mind during lecturing (Kula, 2014).

When the literature was reviewed, it was seen that the descriptions of sub-codes and triggers of the Contingency unit, and the comprehensive descriptions and examples were limited (Rowland et al., 2011). For example, the fact that there isn't any detailed information on the content and triggers of even the most cited code of the Contingency unit, "responding to student's ideas" code, is one of the factors that led to the designing of this study. For this reason, it is important to determine the contingent moments and triggers that lead to "responding to the (un)availability of tools and resources" code in the classroom, which there is not much information about it. However, it is aimed to give more information about the code by determining which sub-codes are included under this code.

With this study, for the first time in Türkiye, the approaches of pre-service mathematics teachers towards unexpected situations they encounter in their teaching processes are conceptualized within the framework of Knowledge Quartet. With the conceptual framework revealed, teachers, and especially novice teachers, can have the opportunity to review their own approaches to responding to the (un)availability of tools and resources. It is also thought that in-service and pre-service mathematics teachers can be guided about what approaches are appropriate for more effective teaching and more supportive of understanding, and what interventions can be made when contingent events occur.

The study was planned to be conducted with student teachers because Peterson and Leatham (2009) states that experienced teachers and teacher educators can often recognize important mathematical moments during the lesson and use them to support student's learning, but especially novice teachers cannot recognize these moments or act professionally (as cited in Stockero & Van Zoest, 2013). It is important to determine the approaches during such situations because inexperienced or pre-service teachers may not be able to decide how they will respond to an unexpected situation or may have difficulties while handling these situations. It is seen as situations that can take time for student teachers who do not have the experience (Rowland et al., 2011). For this reason, it is important to determine how pre-service mathematics teachers approach contingent moments that they may encounter during their lessons. Therefore, the research problem was determined as "How to conceptualize pre-service mathematics teachers' approaches to unexpected situations that require them to responding to the availability of tools and resources that can be used in their teaching processes?" In accordance with research problem, the purpose of this study is to understand the approaches of pre-service mathematics teachers who are facing controversy during the teaching process within the context of responding to availability of tools and resources.

Method

This was a grounded theory study which aimed to conceptualize the pre-service mathematics teachers' responding to availability of tools and resources. Grounded theory emerges especially when there is no satisfactory theory on a certain subject and the subject to be researched is not sufficiently understood (Charmaz, 2006; Punch, 2005; Strauss & Corbin, 1998). Since the sub-codes and their triggers of respond the (un)availability of the tools and resources are not clear enough, the grounded theory was intended to be used. In this context, we aimed to conceptualize the sub-codes and their triggers. As a result of the data analysis, four sub-codes in the context of responding to availability of tools and resources were identified within the approaches of pre-service teachers in relation to contingent moments. Additionally, triggers that cause the surfacing of each sub-code were determined and it was attempted to provide more detailed information regarding the sub-codes.

Participants

The participants in the research were nine senior pre-service secondary mathematics teachers. The participants had almost completed the last semester in the program. The participants took the courses which prepare them to be mathematics teachers such as Calculus, Analytic Geometry, Differential Equations, Algebra, Mathematical Modeling, History of Mathematics, Mathematical Applications with Computers, Mathematical Thinking, etc. In addition to these courses, they also took courses such as Introduction to Educational Sciences, Curriculum Development, Assessment and Evaluation, Classroom Management, etc. Apart from this, there were courses related to school-based placement.

The study was conducted with volunteer pre-service teachers who encountered a contingent moment within the six lesson hours taught within the scope of the Teaching Practice. The participants of the study were determined using theoretical sampling (Patton, 2002), one of the purposeful sampling methods. Theoretical sample means the sample intended to be used throughout the development of the theory (Glaser, 1978; Glaser & Strauss, 1967). In grounded theory, while the initial sample is used to collect the first data in a study, the theoretical sample directs the researcher on where to go and where to collect data (Charmaz, 2006; Neill, 2007).

When creating the initial sampling, it was taken into account that the participants were attending the Teaching Practice at Anatolian High School. The reason why Qualified High School was chosen was the idea that the students would be more successful and would be able to analyze the lessons more because they came within the scope of the exam they took after secondary school, and that the participants would be able to encounter more contingent events. Additionally, one participant taught at the 10th grade land two participants taught at the 11th grade. Thus, it was aimed to examine the participants' approaches to unexpected situations that may arise in teaching a lesson at different grades and at the same grade level but with different subjects and different participants. After the first data collection process was conducted with three participants, it was observed that the categories began to de created.

At this stage, it was wondered how contingent moments might occur in different ways in a different type of school and what approaches pre-service teachers would take, and it was thought that the participants who went to Vocational High School could

contribute to the conceptualization. For this reason, in the continuation of the study, those who continued their teaching practice in Vocational High School were selected as participants. Pre-service teachers who taught subjects that were not included in the initial sample were similarly included in the study at different grade levels. The sub-codes of the data obtained after the observed lessons of the three participants were shaped and their final form was given. However, since it was desired to verify whether there were new sub-codes that might emerge, it was desired to work at different grade levels and on different subjects with participants from both types of high schools. Information about the participants' pseudonym chose by themselves, school type, class, and subject is given in Table 1.

Table 1

Participants' Information

Participants	School Type	Class	Subject
Seyfi	Anatolian High School	10	Trigonometry
Salim	Anatolian High School	11	Matrix, determinant, and linear equation systems
Aysun	Anatolian High School	11	Binomial expansion-probability
Ufuk	Vocational High School	9	Rational numbers
Gülbin	Vocational High School	10	Midsector-height-area of triangular region
Cumhur	Vocational High School	11	Series
Efe	Vocational High School	9	Radical expressions
Sercan	Anatolian High School	10	Trigonometry
Halil	Anatolian High School	12	Derivative

Before conducting their lectures, the participants prepared lesson plans. They conducted their lessons for students in different grade levels. Different grade levels were chosen because of the idea that more diverse categories may emerge. It is also thought that if pre-service teachers teach different course topics and different grade levels, it would be factor in reaching rich categories.

Data Collection Procedure

Participants were asked to prepare a detailed six-hour lesson plan before their teaching. They were given a lesson planning template. The planning template includes the activities and roles of the teachers and their students, the allocated time, the reason for the selection of the activity, and so on, and the sources from which they are used and for what purpose. In light of this information, it is aimed to determine whether the situations that occurred during the lesson are unexpected, whether the participant has changed the plan or not, and what is the approach to the unexpected situation. Participants carried out their teaching in the schools in the direction of the lesson plans. The participants' lessons were recorded using a video camera. They were observed during their teaching and field notes were taken regarding contingent moments. In the field notes the contingent moment and the triggers to cause this contingent moment

were noted. It is aimed to save time by focusing on the relevant moments of the video recording in the coding work. The field notes were used in the initial coding and thus it was decided whether the data reached the saturation. After the categories reached saturation, data collection was terminated. Thus, a total of 54-hour courses of nine pre-service teachers were observed. In order to prevent data loss, lessons were videotaped. While transcription was in process, data familiarity was gained. Transcriptions also provided convenience in the second coding. The semi-structured interviews were performed concerning the contingent moments.

Data Analysis

Initial coding began with field notes taken in class. During data collection process, two researchers performed coding after each lesson and when the code saturation achieved, the data collection process was completed. Thus, a total of 54 hours of lessons by 9 pre-service teachers was examined within the context of the approach towards contingent moments. After the data collection process, video recordings of each pre-service teacher were transcribed and prepared for the second coding. A more detailed coding process has been started with transcript documents. Thus, the data were examined both more thoroughly and the first coding was determined whether there were any cases that were not noticed. With the second coding, the analysis was verified. Then two researchers conceptualized the data. While generating sub-codes, the transcriptions of each lesson were reviewed many times. In the grounded theory process, data analysis began with initial coding, continued with focus coding and then theoretical coding (Charmaz, 2006). An attempt was made to find an answer to how the sub-codes that emerged through theoretical coding could be related to each other while creating the theory. Data analysis continued until no new subcodes emerged. Thus, the sub-codes and their triggers presented in the results were reached. The audio records of the interviews were also transcribed verbatim, and these transcriptions were used to support the findings.

Trustworthiness

Lincoln and Guba (1985) state that credibility, transferability, dependability, and confirmability criteria will be considered in evaluating qualitative research. In order to increase credibility, extracts taken from course transcripts, observation notes and interviews were included while presenting the findings. Also, to increase the transferability of the study, the method, participants, data collection tools and data analysis method were explained in detail. In the study, dependability was tried to be provided by giving detailed information about the data collection process, the created sub-codes, their triggers, and the basic features of the sub-codes. Confirmability was attempted to be ensured by analyzing the data by two researchers and finalizing the sub-codes and triggers by reaching a consensus.

Ethical Procedures

Ethics committee permission was obtained from Dokuz Eylül University The Institute of Educational Science Ethics Board for the study's implementation (08.05.2013, No: 12018877/604.01.02./879849).

Results

When the approaches of pre-service mathematics teachers towards contingent moments were analyzed in which they had to respond to the (un)availability of the tools and resources that may be used in the teaching process, the following sub-codes emerged:

- Demonstrating,
- Using a classroom object,
- Using mathematical software,
- Changing tools-resources.

In the following sections, each sub-code is explained and the triggers that lead to the emergence of these sub-codes are included. Extracts from some participants' lecturing that are thought to best explain each subcodes and its triggers presented, and field notes are also included. Additionally, observation notes are sometimes used, and transcripts of interviews are sometimes quoted to make findings more understandable.

Demonstrating

The demonstrating sub-code is related to situations in which pre-service teachers concretize abstract concepts. By asking students for help or doing it themselves, student teachers realize demonstrating situations that their pupils cannot conceive.

Triggers that motivate pre-service teachers for demonstrating:

- that they are easily accessible,
- ease in reflecting instantaneous changes,
- thought that it would help to achieve the outcome and
- it can provide concretization.

In his first lesson, Hasan conducted his teaching process concerning the learning goals: "The student determines the maximum or minimum point that should be found within the range with the help of the second derivative. The student explains the concepts of concave, convex, and inflection point on the graph of a function." Hasan stated that he would associate the function with distance, the first derivative function with speed, and the second derivative function with acceleration. Hasan's student had difficulty understanding the relationship between the increase in acceleration the change in speed and distance. The lesson regarding this difficulty Hasan's discourse and the actions he has taken are as follows:

Hasan:	*Now I started from position 0. I'm in an accelerated movement. I speed up, since my acceleration is positive it increases my speed. So now my speed was one, I've added an acceleration, and it became three, I started to go faster. I'm starting to go a lot more. The distance I got ...*
Student:	*Is increasing.*
Hasan:	*Is it increasing? What was it at first; I got 1, then 3, then 5. Okay? So, the distance I covered is increased when my acceleration was positive, right?*
Student:	*Yes.*
Hasan:	*Okay, we don't have a problem here. Well, what about the distance I covered when my acceleration is positive, how does it increase? I started to go faster at every turn. The distance increased faster. Increased increasingly. In other words, when my acceleration was positive, it leads to a convexity. Okay?*
Student:	*How was it decreasing increasingly?*

Hasan: *Now.*
Student: *How was it decreasing increasingly?*
Hasan: *Okay. I increased my acceleration, and then I reduced it. What happened to my speed? It is decreasing, but I can still cover distance, because my speed is not 0. My acceleration is now negative. I covered the maximum distance I could. (Demonstrating these by walking)*
Student: *Are you going back?*
Hasan: *I am going back. My acceleration is now negative, my speed is going backwards. What happened when my acceleration went to negative? I've covered the maximum distance, I went back. I took the maximum distance and went back.*

(Drawing this with his hand.)

Hasan: *Because my acceleration is negative. I've covered the maximum distance, I went back. So, what is it? There is a maximum point. Okay? So, when my acceleration is negative, I covered the distance I could, and I had to go back because my speed was not negative anymore. So, if the acceleration is negative, there is a maximum point. Okay?*
Student: *Okay.*
Hasan: *It was negative, I was going backwards. My acceleration was negative. My acceleration went to positive, reduced my speed, and reduced it to 0. The turning point is 0, where my acceleration made my speed 0. Then I went to the positive. Because my acceleration is positive, my speed went up and I went back the last point I could go. (Demonstrating these by walking)*
Student: *I hit the bottom.*
Hasan: *Okay, we can say that. It's also the minimum point. I went backwards, the speed increased, and the minimum point occurred.*

(Drawing this with his hand.)

Hasan: *So, when my acceleration becomes positive and I was going backwards, I started to go positively forwards. I had a minimum point. Okay, do we understand?*

When Hasan realized that his students had difficulty in understanding, he started demonstrating by walking in classroom and moving his hands. In this way he tried to make his students understand by concretizing the physical interpretation of the derivative. Hasan walked in the classroom by increasing or decreasing his speed according to his purpose, showed how the graph would look like with his hands. The observational note taken by the researcher regarding this section of Hasan's lecturing is given below:

> While talking about the physical interpretation of the derivative, he conducted a mutual question-and-answer session with his students. He questioned his students about the origins of their thoughts. He tried to figure it out by walking because he realized that his students were experiencing difficulties in understanding accelerated movement. At this point, both he and his students made comments on the increase and the decrease in acceleration. Hasan showed the maximum and minimum points of the graph by drawing with his hand on the air (A Section from Hasan's 1st Lesson Observation Note).

Similarly, Hasan expressed his thoughts in the interview conducted with him after the lesson:

> When I talked about the concepts such as speed, acceleration and distance, they had difficulties with understanding. I realized that I couldn't help them by lecturing on the board; I started walking into the classroom. I speeded up, down and walked forwards and backwards (A Section from Hasan's 1st Lesson Interview)

Using a Classroom Object

The sub-code of using a classroom object is concerned with the inclusion of an element in the classroom environment by the participants in order to ensure that students have a better understanding. Pre-service teachers integrate an object they think will serve for the purpose by correlating it with the subject of the lesson.

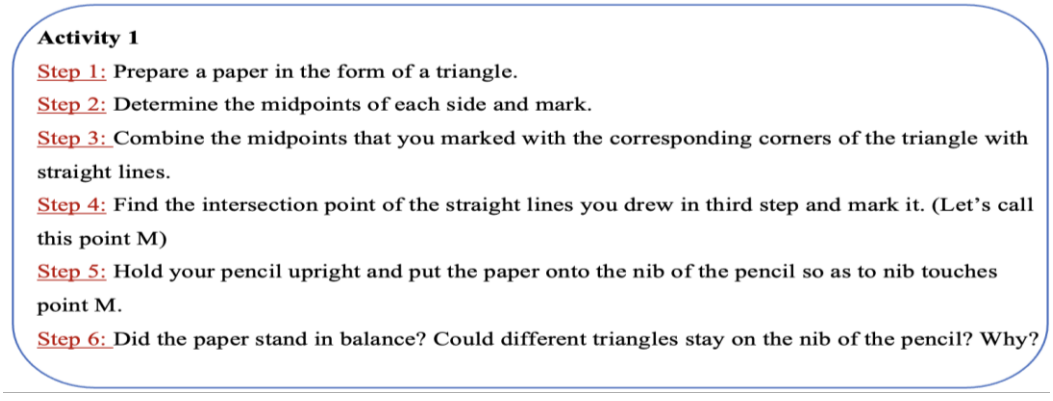
Triggers that motivate pre-service teachers for using a classroom object,

- that they are easily accessible,
- establishing a correlation with different disciplines,
- increasing the comprehensibility of the course subject, and
- the thought that it will help students to concretize an idea.

In her first lesson, Gülbin conducted her teaching with the activities she prepared for the learning goal: "The student determines that the medians in triangles intersect at one point and applies this in exercises." Gülbin handed out the activity in Figure 1 to her students which she thought would help students figure out the centroid.

Figure 1

The Activity Prepared by Gülbin for Her First Lesson


Activity 1

Step 1: Prepare a paper in the form of a triangle.

Step 2: Determine the midpoints of each side and mark.

Step 3: Combine the midpoints that you marked with the corresponding corners of the triangle with straight lines.

Step 4: Find the intersection point of the straight lines you drew in third step and mark it. (Let's call this point M)

Step 5: Hold your pencil upright and put the paper onto the nib of the pencil so as to nib touches point M.

Step 6: Did the paper stand in balance? Could different triangles stay on the nib of the pencil? Why?

After she distributed the activity, despite not being included in the lesson plan, she stated that the table, chair, and camera in the classroom stand in balance, as follows:

Gülbin:	*Friends, for example the table and the chair stay in balance. How can they? Look, there is this camera for example, the camera stand stays in balance. Well, how come these objects stand in balance?*
Student:	*With their legs.*
Gülbin:	*With their legs. Well, what if we put their legs in a different position, would they still stand in balance?*
Student:	*Yes.*
Student:	*No.*

Student: *If we center them on their centroid, they would.*
Gülbin: *Your friend said that if we centered then on their centroid, they would have. Anyone who agrees or disagrees? If you agree or disagree, why?*

Gülbin gave examples of table and chair and stated that they stand in balance. When she noticed the camera legs, she included them to her examples. Thus, she tried to capture the attention and interest of her students in order to correlate the concept of centroid with physics course. In addition, she helped them to concretize the concept by relating it to daily life. She created a platform in class for discussing on how to find out the position of a centroid. The observation note taken by the researcher regarding this section of Gülbin's lesson is given below:

> Gülbin distributed the activity to her students. She asked her students how the table and chair stand in balance (not included in the lesson plan). At that moment, the tripod caught her eyes. She said that the camera leg stands in balance. In this way, she tried her students to reach at the concept of centroid (A Section from Gülbin's 1_{st} Lesson Observation Note).

Similarly, Gülbin expressed her thoughts in the interview conducted with her after the lesson:

> After I distributed the activity, I said that the table and chair were standing in balance. At that moment, they crossed my mind, and then camera legs caught my attention. I said that it was also standing in balance. I asked them how it was standing in balance considering whether they can arrive at centroid. They could have remembered it from the physics course. I also thought to make them see the relationship between math and physics. After all, the table, chair, and the camera are before their eyes (A Section from Gülbin's 1st Lesson Interview).

In her fourth lesson, Gülbin asked her students what they think when they heard "height", with an intention towards learning goal: "The student can calculate the height of a triangle". The students responded Gülbin as following:

Gülbin: *What would you think about height if we're not in geometry lesson? What does height mean?*
Student: *We know height from physics.*
Gülbin: *Well, what if I wasn't going to school, wouldn't I know anything about height? Don't you ever use height out of school?*
Student: *No.*
Gülbin: *Where do you use it, for instance?*
Student: *While measuring.*
Gülbin: *For instance?*
Student: *(cannot be understood)*
Gülbin: *Well, how was those heights measured?*
Student: *With a measuring stick.*
Gülbin: *Yes. How, for instance? If I say the height of the ceiling from the floor, how can be measured? Where do I measure exactly? Or when I measure the height from the floor to the lamp, where do I exactly measure?*
Student: *From the ceiling to the floor.*
Gülbin: *Floor, where?*
Student: *Vertically.*
Gülbin: *Vertically. 90 degrees. Why do I take 90 degrees?*
Student: *As the shortest distance.*

A student stated that they used height in physics classes. Gülbin directed them to express how they used height in their daily lives. She wanted them to tell how they measure the length. When her students could not draw a conclusion that she wanted, Gülbin integrated classroom objects into her lecturing by asking students to state the distance from the floor to the ceiling or from the lamp to the floor. Based upon the lamp in the classroom Gülbin tried to make her students grasp the concept of height. The observation note taken by the researcher regarding this section of Gülbin's lesson is given below:

> Gülbin asked her students what comes to their mind when they heard "height". Her students gave different answers. When she raised the topic to measuring of height, she asked how they measured. Then, she let them deduce perpendicularity by asking how the distance from the lamp on the ceiling to the floor could be measured (A Section from Gülbin's 4t^{h} Lesson Observation Note)

Using Mathematical Software

The sub-code of using of mathematical software is related to integration of technology into teaching although this software is not included in the lesson plan. Participants use mathematical software to grab students' attention, as well as ensuring students to concretize the concepts in a shorter period by taking advantage of the dynamism of the software.

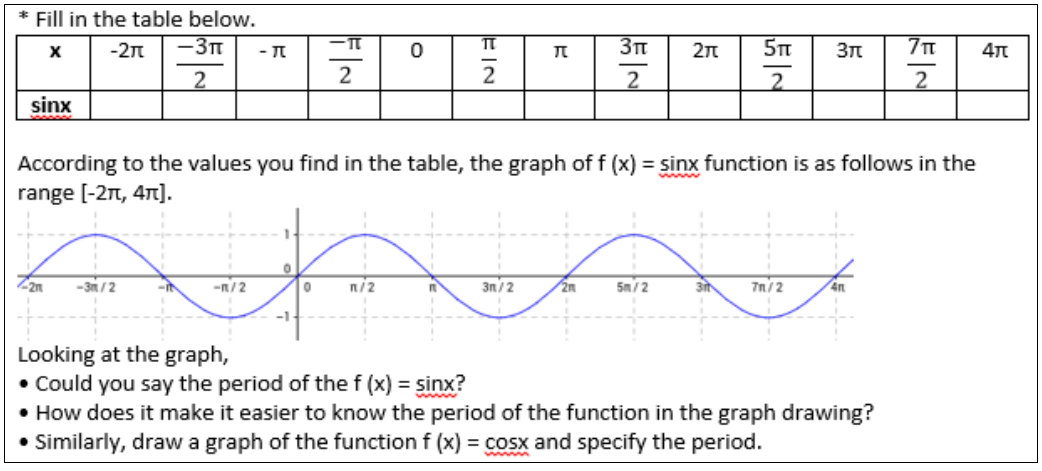
Triggers that motivate pre-service teachers for using mathematical software,

- thinking that it will help in generalizing,
- thinking that it will ease making comparisons,
- thinking that students can make choices among alternatives,
- thinking to deal with student difficulties,
- to include different examples,
- to demonstrate.

In his fifth lesson, Seyfi conducted his teaching with the activities in Figure 2 he prepared for the learning goal: "The student can define periods and periodic functions; find periods of and draw graphics of trigonometric functions". findings.

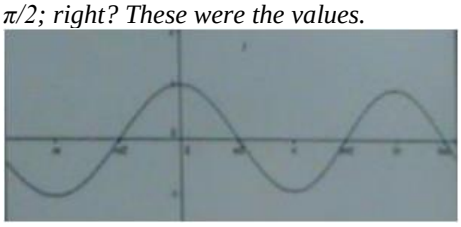
Figure 2

The Activity Prepared by Seyfi for His Fifth Lesson



Seyfi's students had difficulties in drawing f(x)=cosx graphic which was the last step of the activity. So, he turned on the computer and included using software to his lecturing and drew the graph of the function by GeoGebra.

Seyfi: *It says "Similarly, draw a graph of the function f(x)=cosx and specify the period." It actually says, find the period of cosx. When I took a glance at the classroom, friends, I couldn't see anyone who could draw the graph completely. I thought we could do this way. Here is the software called GeoGebra. I draw the graph on the software and let's decide together to its period. Besides, we can see what the period would be easier. I'm going to draw now the graphs with the help of the software. It's right before your eyes. Then we'll explore the periods for these functions. Alright? The, we'll try to figure out how these periods are changing, depending on what. What was happening in our x-axis? π becomes π/2; right? These were the values.*

Geogebra: 

Seyfi: *The graph of cosines x, is that correct?*
Student: *Yes.*
Seyfi: *Let's try to say something about the period of our cosines x.*
Student: *(cannot be understood)*
Seyfi: *Then 0 and 2π . Now, let's take little notes. We've already said for the sinus x, it was 2π , right?*
Student: *What happens to π ?*
Seyfi: *Friends, does it repeat one for π ?*
Student: *0 and 2π .*
Seyfi: *Then, what is the period?*
Student: *0 and 2π .*

When Seyfi saw that students were having difficulties in drawing graphs, he opened the GeoGebra software and draw the graph of the function although it was not included in the lesson plan. He also asked students to discuss the period of function through the graphic that he had drawn. Thus, the made his students arrive what will be the period of f(x)=cosx function. The observation note taken by the researcher regarding this section of Seyfi's lesson is given below:

> He gave Activity 5 to his students. They talked about the examinations on f (x) = sinx function on the activity paper. He then drew the graph of the f (x) = cosx which is other phase of the activity and gave his students time to find the period. At this stage, he walked around the classroom to see what students were doing. He answered questions of the students. Then he said that there was nobody could exactly draw the graph and he would draw it with software. He said that they would see the periods easier. Using the scrolling property of the program he moved along the x-axis and could show the period of the graph more clearly. He did not mention that he would use the software in the lesson plan (A Section from Seyfi's 5th Lesson Observation Note).

In the later part of the lesson, he has also made use of the GeoGebra software while generalizing about the periods of trigonometric functions. Having seen that the software served his purpose, Seyfi expressed his thoughts in the interview conducted with him after the lesson:

> In the previous activity, we talked about the periods with the examples from daily life. Well, like TV series and so on. Then, we examined another periodic function which I gave the graph of. Now I have also given this activity to distinctively show the trigonometric functions. I walked around the classroom while the students were drawing the graph of cosx, some students were making mistakes. GeoGebra came to my mind, teacher. We were taught in technology course at the university, I turned on the computer thinking that it would be useful. I drew the graph on the software, they liked it a lot. I even used it generalizations in the later part of the lesson. It made it convenient for me too, my teacher. We scrolled; we did (A Section from Seyfi's 5th Lesson Interview).

Changing Tools-Resources

The changing tools-resources sub-code is related to the situations in which student teachers change tools and resources they planned to use. Student teachers remove the tools and resources that they have previously decided to use from their teaching and tend towards different tools and resources for the learning goal process.

Triggers that motivate student teachers for changing tools-resources,

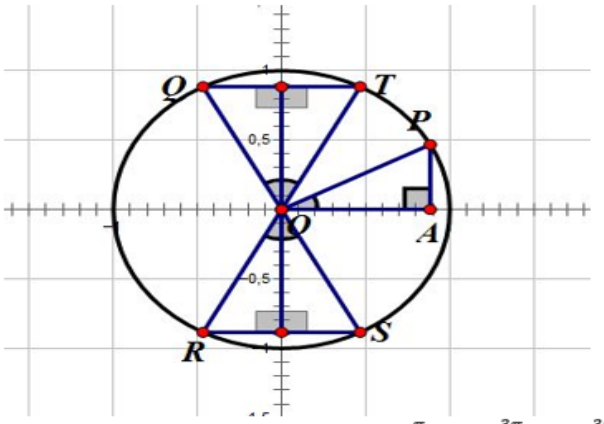
- the tools-resources cause students to get bored,
- thinking that they are not helpful for teaching,
- unable to reach tools-resources.

In his first lesson, Seyfi made use of two different activities for the learning goal: "The student can write trigonometric ratios of $k\pi / 2 \pm \alpha$, with $k \in Z$, in terms of trigonometric ratio of α." In second lesson, Seyfi did not use Activity-3 in Figure 3, which was actually in his plan.

Figure 3

The Activity Prepared by Seyfi for His Second Lesson

Activiy-3:



Using the unit circle above, find the trigonometric ratios of $\frac{\pi}{2}+\alpha$, $\frac{3\pi}{2}+\alpha$, $\frac{3\pi}{2}-\alpha$.

Fill the following tables according to the examples.

x	$\frac{\pi}{2}-\alpha$	$\frac{\pi}{2}+\alpha$	$\frac{3\pi}{2}-\alpha$	$\frac{3\pi}{2}+\alpha$	$\frac{5\pi}{2}-\alpha$
sinx	cos α		-cos α		
cosx	sin α		-sin α		sin α
tanx			cot α		
cotx					

x	sinx	cosx	tanx	cotx
90- α				
90+ α			-cot α	
270- α	-cos α			
270+ α				
450+ α				

The reason that Seyfi did not use this activity is that he observed that his students got bored of the activities he used in his first lesson and that he did not find the activities helpful. Seyfi expressed his thoughts in the interview conducted with him after the lesson:

> I prepared all those activities, but they did not follow in the first lesson. It sounded unfamiliar to them, I guess. So, they got bored. Then I thought that they would get bored and would not follow the lesson, I said to myself that I would then give up the activity and they would follow. We went on from the work sheet (A Section from Seyfi's 2nd Lesson Interview).

Discussion and Conclusion

As a conclusion of the conceptualization of pre-service teachers' approaches to contingent moments they encounter in teaching in the context of responding to the availability of tools and resources; the sub-codes of demonstrating, using a classroom object, using mathematical software, and changing tools-resources were identified. Triggers that cause these sub-codes to occur are also identified in this study.

Pre-service teachers have shown demonstrating approach with the thought that they are easily accessible, it eases reflecting instantaneous changes, it will help to achieve the outcome, and it can provide concretization. In this way, they demonstrated abstract situations that students could not concretize. On the other hand, participants made use of classroom objects for their teaching with the thought that it would help students to concretize an idea, that they are easily accessible, to establish a correlation with different disciplines, and that it increases the comprehensibility of the course subject. Rowland et al. (2011) stated that, the pre-service teacher included the 1-100 counting cards that he noticed at the moment, in his lecturing although it was not in the lesson plan.

Pre-service teachers have integrated mathematical software into their teaching because they thought that it would help making generalizations or comparisons, that students can make choices among alternatives, to deal with student difficulties, and that they realized the necessity to concretize. Also, Laborde (2001) stated that using digital technologies, such as the dynamic software package GeoGebra, can place significant demands on teachers' mathematical knowledge and hence provide opportunities for making such knowledge visible and available for exploration (as cited in Bretscher, 2019). Corcoran (2013) stated that the students had difficulty because the pre-service teacher conducted the lecturing only verbally and as in the lesson plan. However, while they discuss the concepts of learning and practice of teachers, Ball and Cohen (1999) argue that these concepts include the teacher to size up from moment to moment (cited in Stockero & Van Zoest, 2013). From this point of view, it is important for pre-service teachers to concretize the situations that are not understood during teaching even though they were approached abstractly in the lesson plan.

Pre-service teachers resorted changing the tools-resources with the thought that the tools-resources in the lesson plan cause students to get bored, and that they are not helpful for teaching. By removing some of the tools-resources, the pre-service teachers turned to different tools and resources to make their students comprehend the intended learning goal. In Johnson's (2011) study, when the Smartboard stopped working after a pre-service teacher started her lesson, she could not continue through the presentation she prepared. She could not use the Smartboard, but she had a whiteboard and could

share with her students what she remembered from the plan. To address such situations effectively, it is important that pre-service teachers undergo comprehensive preparation.

Pre-service teachers are expected to be informed about different contingent moments. In this respect, it is considered that this study, in which the contingent moments and the possible approaches to these moments that mathematics pre-service teachers who have not yet have the adequate experience would encounter were identified, will provide important contributions to both pre-service teachers and the teacher training process. Compared to experienced teachers, pre-service teachers may have difficulties in noticing the deficiencies in their teaching and overcoming these difficulties since they are not experienced (Rowland et al., 2011). Mason (1998) states that the greatest difference between experienced and novice teachers is "the form and structure of their attention" (cited in Stockero & Van Zoest, 2013). As can be seen in Kula (2011), while some pre-service teachers may overcome some contingent moments, others may not. Similarly, Kgothego and Westaway (2023) revealed that teachers who prepared their lessons through lesson study process did not want to deviate from the lesson plan. Nevertheless, it has been suggested that teachers should exhibit flexibility in the implementation of their lesson plans to better align with the mathematical needs of their students. For this reason, in Special Teaching Methods, Instructional Technologies and Material Development, and Technology Assisted Mathematics Teaching courses, it is important to address the approaches that help understanding students and the approaches that are focused on when and for what the technology can be used in class. In addition, it is suggested that the approaches related to students' thinking in Mathematical Thinking courses and the approaches such as individual observation, examination, evaluation and development of teacher interventions in Teaching Practice courses should be included in the curriculum of existing courses.

Given that pre-service teachers' experiences in real class environment are not adequate, they cannot be expected to have complete knowledge of contingent moments. This, once again, underlines the importance that pre-service teachers should be trained and gain experience in this direction. Mason (1998, 2011) suggests that improving the awareness of teachers may help to increase in their attention to what they should focus on their lecturing (cited in Stockera & Van Zoest, 2013). Informing the students about what difficulties they may face with in which course topic, what misconceptions they may have and what common mistakes they can make (Ryan & Williams, 2007) can also help them to be prepared for surprises and to have insight (Rowland et al., 2011).

It is suggested for the future studies to determine which of the exhibited approaches are beneficial for students to learn better and for an effective mathematics teaching. It is now possible to investigate which of the exhibited approaches to contingent moments effects comprehension and how. This study, which was conducted with pre-service teachers, may also be conducted with experienced teachers. By raising awareness to the identified approaches and examining first and last lessons of pre-service teachers, the effectiveness of such approaches can be researched. The improvement process of the pre-service teachers' approaches to contingent moments can be observed. It will be possible to examine whether similar sub-codes will emerge for different schools, experienced or inexperienced teachers and different countries.

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Statement of Responsibility

Both authors contributed to the whole process such as data collection, initial conceptualization, drafting of the original manuscript, methodology, etc. of the study.

Conflicts of Interest

The authors have declared that there are no potential conflicts of interest regarding the content of the article.

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The Impact of Innovative Technological Practices for Gifted Children's Education on Support Classroom Teachers' Attitudes and Opinions towards Technology Use

Özel Yetenekli Çocukların Eğitimi için Yenilikçi Teknolojik Uygulamaların Destek Eğitim Odası Öğretmenlerinin Teknoloji Kullanımına Yönelik Tutum ve Görüşlerine Etkisi

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ABSTRACT: The aim of this study is to determine how innovative practices aimed at meeting the educational needs of gifted children, taught during activities, influence the attitudes and opinions of resource room teachers towards the use of technology in education. This study, conducted with 30 teachers working in the Southeastern and Eastern Anatolia Regions, employed a mixed-methods approach and included various activities such as animations, augmented reality, educational games, and STEAM. Data were collected through the attitude scale and diaries towards the use of technology in education. The results indicate that teachers' attitudes towards technology use did not differ by gender and that innovative applications were beneficial for all teachers. However, deficiencies were observed in teachers' ability to adapt to technologies related to coding, engineering, and STEAM. To address these deficiencies and keep technological knowledge and skills up to date, it is recommended to organize regular professional development programs and seminars.

Keywords: Gifted children, innovative practices, resource room teachers, technology use in education.

ÖZ: Bu çalışmanın amacı, özel yetenekli çocukların eğitim ihtiyaçlarına yönelik hazırlanan yenilikçi uygulamaların öğretildiği etkinliklerin, destek eğitim odası öğretmenlerinin eğitimde teknoloji kullanımına yönelik tutum ve görüşlerini nasıl etkilediğini belirlemektir. Güneydoğu ve Doğu Anadolu Bölgesi'nde görev yapan 30 öğretmenle gerçekleştirilen bu çalışmada karma yöntem kullanılmış, animasyon, artırılmış gerçeklik, eğitsel oyun ve STEAM gibi çeşitli etkinlikler düzenlenmiştir. Veriler, eğitimde teknoloji kullanımına yönelik tutum ölçeği ve günlükler aracılığıyla toplanmıştır. Sonuçlar, öğretmenlerin teknoloji kullanımına yönelik tutumlarının cinsiyete göre farklılaşmadığını ve yenilikçi uygulamaların tüm öğretmenler için faydalı olduğunu göstermektedir. Ancak öğretmenlerin kodlama, mühendislik ve STEAM alanlarındaki teknolojilere uyum sağlama konusunda eksiklikler yaşadığı gözlemlenmiştir. Bu eksikliklerin giderilmesi ve teknolojik bilgi ile becerilerin güncel tutulabilmesi için düzenli mesleki gelişim programları ve seminerlerin yapılması önerilmektedir.

Anahtar kelimeler: Özel yetenekli çocuklar, yenilikçi uygulamalar, destek eğitim odası öğretmenleri, eğitimde teknoloji kullanımı.

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In the 21st century, the close relationship between education and digital technology has also brought about efforts to transform educational systems. This transformation aims to keep up with the rapid changes brought about by the digital age and to equip students with today's skills (Ersoy & Gurgen, 2021; Kiroglu & Guven, 2024). The integration of technology into education not only enriches learning experiences but also has the potential to provide students with a more effective and interactive learning environment (Erdogmus & Cagiltay, 2009; Kucuk et al., 2024; Zengin et al., 2024).

The way technology use is shaped by gender and its implications in the field of education remain subjects of uncertainty and debate. Differences in technology use and attitudes observed between men and women are linked to social and biological factors. Specifically, demographic characteristics such as gender, ethnicity, religion, social, and economic status are noted to influence individuals' attitudes towards technology and their usage patterns (Anandhita & Ariansyah, 2018; Oldeweme et al., 2021; Rahiem, 2020; Wilhelm, 2018). However, some studies question the extent of these differences. Gokbulut and Coklar (2018) found no significant differences in technology use levels among teachers based on gender. On the other hand, Oktay and Cakir (2012) discovered that woman teachers had higher attitudes towards technology compared to their man counterparts. Menzi et al. (2012) reported that, according to their study on teacher candidates' technology use competencies, man teacher candidates had higher technology usage competencies compared to woman candidates. Gunes and Buluc (2017) demonstrated that man teachers were more effective in using educational technologies and software in their classes, as well as in acquiring knowledge about new technologies, compared to woman teachers. Sayginer (2016) also found that man teacher candidates had higher computer competency levels than woman candidates. Additionally, according to an Organisation for Economic Co-operation and Development (OECD) report, Turkey is among the countries where the largest gender differences in information processing skills are observed (OECD, 2013). These results highlight that the gender variable plays a significant role in technology use and education, yet the diversity of results across different studies underscores the need to understand these dynamics. Including the gender variable in the analysis is a critical step in identifying gender-based differences in technology use in education and in designing more effective educational policies. Gender analysis plays an important role in determining the necessary support and resources for teachers to use technology more effectively in education. Therefore, a comprehensive analysis of the gender variable is essential for enhancing the effective use of technology in education and supporting gender equality.

The widespread use of technology in education increases the opportunity to provide more specific and effective solutions to the learning needs of student groups. Therefore, the proliferation of information technologies in education adds particular value to the education of gifted children (Caliskan, 2017; Ozmen & Komurlu, 2011). While information technologies can effectively enhance the learning environments of typical students (Isman, 2002; Ocak & Kus-Serin, 2024), they are also highly effective in the education of gifted individuals (Gunduzoglu, 2023; Diffily, 2002). These technologies play a significant role in better meeting the individual needs of these students and maximizing their potential. According to Ozmen and Komurlu (2011),

information technologies enable gifted individuals to more easily demonstrate their abilities and facilitate better integration with learning environments. Additionally, these technologies are effective in reducing peer pressure, providing students with opportunities to demonstrate and develop their creativity and mathematical abilities, and promoting collaboration by increasing communication and interaction. Thus, gifted children can experience a more effective learning experience by using information technologies (British Educational Communication and Technology Agency [BECTA], 2001). Gifted children generally require more personalized and in-depth learning experiences beyond standard educational methods. Activities can enhance teaching effectiveness by considering these individual differences and can be tailored to the students' interests, abilities, and learning styles. Activities aimed at developing skills such as problem-solving, creative thinking, and critical analysis can help gifted children better unlock their potential.

Advanced countries' education systems focus particularly on the education of gifted children and have developed various educational models. For example, in Germany, there is no uniform education system nationwide, and in some states, separate classes for gifted children cannot be opened in state schools. However, it is possible for private schools to open separate classes or schools for gifted children. In New Zealand, a flexible and school-centered education model has been adopted for gifted individuals. The Ministry of Education's website in New Zealand provides information and support services for gifted children (TGNA Commission, 2012). In South Korea, with a law enacted in 2002, the education of gifted children has been standardized, and teacher training has become an important part of this process. In Canada, education for gifted individuals is provided within the formal education system, and particularly in the province of Ontario, differentiated educational opportunities are offered to students. In Russia, the Sozvezdie School, established in 1992, offers a special program for the education of gifted individuals. In the UK, various opportunities such as early school entry, grade skipping, and individual mentoring are provided to gifted children (TGNA Commission, 2012).

According to the definition made by the Ministry of National Education (MoNE) in 2013, gifted individuals are individuals who demonstrate performance at a higher level than their peers in terms of general or special talents. However, education programs in Turkey are generally prepared considering the learning capacities of typical students. This creates an educational environment that does not adequately meet the needs of gifted children (Levent & Bakioglu, 2013). In this context, there is a need for the design of programs and education tailored to gifted children and for strategies and recommendations to meet the educational needs of these students in existing educational environments (Levent, 2014). Considering the increasing demand for differentiated programs adapted to the education system in our country, concrete steps need to be taken in this field (Sak et al., 2015). The importance of support education room services is increasingly recognized to meet this demand. The support education room is designed to provide additional support education in areas where full-time inclusive/integration education students and gifted children need in accordance with their individual needs (MoNE, 2018). The implementation of support education rooms brings many benefits. Providing support opportunities tailored to the individual needs of the student helps the student complete topics that are ahead of their peers. Also, providing individual

attention and support contributes to finding solutions to the student's behavioral problems. Thus, the student overcomes behavioral problems and is accepted and valued by the class, school, and community. Receiving education in a support education room for students with disabilities prevents disruptions in the operation of education in the general education classroom and enables normally developing students to benefit from educational opportunities to the fullest. The participation of individuals with special needs in the support education practice ensures that they show positive academic and behavioral development (Asik, 2023; Kale & Demir, 2017; Opengin, 2018; Semiz, 2018).

Due to geographical location, social and cultural characteristics, especially in the Southeastern and Eastern Anatolia regions, the awareness level regarding the education of gifted children is low, and the educational opportunities for these students are limited. It is important for support education room teachers working in these regions to provide education that is suitable for the potential of gifted children (Nar, 2017). Teachers working in support education rooms in our country encounter various difficulties in providing students with unique and effective education. In a study by Al Khateeb and Hadidi (2009), it is stated that there is a lack of technology and resources in support education rooms, while Aydin (2015) emphasized that teachers experience inadequacy in materials, space, and equipment, and suitable materials for students' needs cannot be obtained. Similarly, Guven (2021) also concluded that the physical conditions of support education rooms are inadequate. In this context, increasing the proficiency of these teachers in technology usage and developing their awareness of innovative practices in science are crucial to provide more effective and innovative education to their students.

The continuous updating of students' and teachers' skills and competencies enhances the importance of technology in the field of education (Gulcu et al., 2013). In this context, it has been determined that class and subject teachers working in support education rooms generally lack sufficient professional knowledge and experience, leading to difficulties in the education of students with special needs (Fazlioglu & Dogan, 2013; Kartopu, 2013; Pektas, 2008). However, existing studies have primarily focused on identifying these issues and have not sufficiently addressed solutions. Additionally, these studies often overlook practical strategies for implementing innovative educational practices and how teachers can effectively use technology. The most significant contribution of this study is the organization of concrete activities aimed at directly providing teachers with innovative practices for addressing the educational needs of gifted children. By focusing on STEAM (Science, Technology, Engineering, Arts, Mathematics) areas and offering activities related to robotics and coding, this study aims to help teachers deliver more effective education to their students. This approach seeks to equip teachers with practical knowledge on how to use technology effectively and to enhance the quality of education for students. This study aims to determine how activities teaching innovative practices prepared for the educational needs of gifted children, within the scope of the TUBITAK 4005 “Journey to Innovative Practices of Science with Support Education Room Teachers” project, affect teachers' attitudes and opinions towards the use of technology in education. In line with this aim, the following questions were addressed throughout the study:

- Do teachers' attitudes towards the use of technology in education differ depending on gender? Is there a significant difference in attitudes towards technology use in education between woman and men teachers?

In the context of the "Journey to Innovative Practices of Science with Support Education Room Teachers" project, what feedback have teachers provided regarding the skills they have acquired, their technological learning experiences, and their strengths and weaknesses in using technology? Understanding the impact of activities organized for support education room teachers on their attitudes and opinions towards technology usage can be a valuable opportunity to enhance the quality of education provided by teachers. Increasing teachers' exposure to innovative technologies such as robotics and augmented reality and enhancing their skills in transferring these technologies to students can contribute to the more effective use of educational technology potential and maximizing the potential of gifted children.

Method

This study constitutes a part of the "Journey to Innovative Practices of Science with Support Education Room Teachers" project. Mixed methods were chosen for this study due to various reasons such as allowing the combination of numbers and words, facilitating the integration of reasoning methods (induction and deduction), enabling the answering of questions that cannot be addressed by a single research method, and allowing for the elaboration and enrichment of study results.

As a research method, mixed methods involve the collection and analysis of both quantitative and qualitative data at various stages of the study process, guided by philosophical assumptions. Mixed methods focus on compiling, analyzing, and integrating quantitative and qualitative data within a single study or a series of studies. As noted by Creswell and Plano-Clark (2007), the integration of quantitative and qualitative data is the most significant premise to better understand the research problem compared to methods that collect only one type of data. Mixed methods are particularly suitable for studies where a single type of data is insufficient, where the results need to be generalized during the study, where the results need to be clarified, and where an additional method is used. It is necessary to make some stages of the research more meaningful and understandable.

In the study, an explanatory design, which is one of the mixed methods designs, was used. There are four basic points to consider in selecting the most appropriate design type for mixed methods studies. These are the level of interaction between stages, the relational priority of stages, the timing of stages, and the integration of stages. The explanatory design is a mixed methods design where the researcher conducts a quantitative stage initially and then begins to search for specific outcomes in the second stage. The second qualitative stage is applied to further explain the relevant results, and the focus of the design is on explaining these results. The general aim of the explanatory design is to use the qualitative stage to explain relationships and trends within quantitative data (Creswell et al., 2003). In this design, first, the teachers' attitudes towards the use of technology in education were determined through quantitative data, and numerical data were collected using an attitude scale. In the second phase, qualitative data were collected to gain a deeper understanding of the teachers' perspectives, and content analysis was conducted on the journals. Thus, the

general trends and results obtained from the quantitative data were explained in more detail and contextually through the qualitative data, providing a deeper understanding of the teachers' attitudes and experiences regarding technology use.

Ethical Procedures

Ethical approval for this study was obtained with decision number 6 dated 23.12.2021 from the Ethics Committee of Social and Humanities Research at Firat University. Written consent was obtained from the participating teachers, and they were provided with information about the process, purpose, and outcomes of the study to ensure their understanding. The identities and personal information of the teachers were kept confidential. Researchers were vigilant to minimize any biases during the data collection and analysis processes.

Participants

The study was conducted with 30 support education room teachers (16 woman, 14 man) working in the Southeastern and Eastern Anatolia Regions, and to ensure the confidentiality of the teachers, pseudonyms were used instead of their real names. Criterion sampling, one of the purposive sampling types, was used in determining the study group. Purposive sampling involves selecting rich situations in terms of information related to the purpose of the study to conduct in-depth research. In criterion sampling, which is one of the types of purposive sampling, the sample is composed of individuals, events, objects, or situations with characteristics identified for the problem (Yildirim & Simsek, 2011). The following criteria were considered in selecting teachers:

- Teachers working in state schools,
- Teachers serving in support education rooms in the Southeastern and Eastern Anatolia Regions or considering this duty,
- Equal or balanced number of man and woman teachers,
- Teachers with postgraduate education,
- Teachers willing to develop and conduct research.

Data Collection Tools

The “Attitude Scale towards the Use of Technology in Education”, developed by Ozturk (2006), consists of 39 attitude statements, with 15 being positive and 24 negative, using a 5-point Likert scale. The scale consists of three dimensions. The first dimension, “the reflection of technology use in education on teaching processes”, includes 16 items. The second dimension, “self-development in technology use in education”, comprises 14 items. The third dimension, “technology use in education and classroom management”, contains 9 items. The positive items on the scale are scored from 5 to 1 with options “Strongly Agree = 5”, “Agree = 4”, “Undecided = 3”, “Disagree = 2”, and “Strongly Disagree = 1”, while the negative items are scored inversely from 1 to 5. The Cronbach's Alpha reliability coefficient of the scale was found to be 0.90. The scale was administered to participant teachers as a pre-test and post-test.

As part of the study, teachers were asked to keep a journal to share their opinions, and experiences based on the activities and observations conducted during the study. Two guiding questions were asked to encourage teachers to express their opinions, and experiences clearly and openly. The questions included in the journal are listed below:

- What achievements do you think you have obtained from the activities you participated in during the day? Please mark (Learning and innovation skills: Creativity and innovation, critical thinking, problem-solving, communication, collaboration; Information, media, and technology skills: Information literacy, media literacy, information and communication technology literacy; Life and career skills: Flexibility and adaptability, entrepreneurship and self-direction, social and intercultural skills, productivity, leadership).
- What did you learn technologically in the project? What are your technological strengths and weaknesses?

The journals collected from teachers at the end of the same day contain information about the gains they obtained from the activities they participated in during the day and what they learned technologically, as well as their strengths and weaknesses in technological terms.

Research Process

The TUBITAK 4005 "Journey to Innovative Practices of Science with Support Education Room Teachers" project was conducted in Elazig province between October 23th and 25th, 2021. A total of 23 different activities were organized within the scope of the study, and these activities were introduced to the teachers by expert academics. The activities held during the study included various methods such as animation and simulation, augmented reality, computational thinking, digital games, educational games, mobile practices, gamification, sports and arts, discussion (seminar, panel vb.), and STEAM (Science, Technology, Engineering, Arts, Mathematics). These activities aimed to provide teachers with a broad perspective on innovative practices, developments in the STEAM field, and methods to support students' special abilities. The activities conducted during the study are presented in Table 1.

Table 1

Activities Conducted During the Study

Days	Activity Names
1st day (October 23, 2021)	Project opening
	Pre-test implementation
	Characteristics of gifted children and educational needs of gifted children
	STEAM theory and practices
	Introduction to robotics through Milo Science
	Fastest race car
	Evaluation of the day-1
2nd day (October 24,	Solar-powered car

2021)	Earthquake simulator
	Designing my dreams with a 3D pen
	My dream car
	Researcher teachers building a theme park I
	Researcher teachers building a theme park II
	Evaluation of the day-2
3rd day (October 25, 2021)	Augmented reality activity with Aurasma
	Augmented reality activity with Quiver Education app
	Smart projects with Arduino
	Creating interactive exams with Kahoot! app
	Creating interactive exams with Powtoon app
	My propeller paper car
	Post-test implementation
	Evaluation of the day-3
	Closing and document submission

Table 1 summarizes the activities and daily schedule from October 23-25, 2021. According to the table, on the first day, a total of seven activities were conducted, including STEAM theories, an introduction to robotics, building the fastest race car, and the day's evaluation. On the second day, seven activities were held, featuring amusement park construction, an earthquake simulator, a solar-powered car, and 3D design. The third day included nine activities, such as augmented reality practices, robotic programming, and effective presentation creation. In total, 23 different activities were conducted throughout the course.

Photographs of the activities conducted during the study process are presented in Figures 1, 2, and 3.

Figure 1

Photograph of the Introduction to Robotics through Milo Science Activity

Figure 2

Photograph of the Earthquake Simulator Activity

Figure 3

Photograph of the Building an Amusement Park II Activity

Researchers play significant roles in the successful execution of the study. They planned and designed the activities at the beginning of the study. When designing the activities, special emphasis was placed on creating an effective and innovative teaching process tailored to the educational needs of gifted children. Each activity was meticulously planned with consideration of these children's characteristics and educational requirements. The design of the activities prioritized active teacher participation and hands-on learning methods, ensuring that teachers had the opportunity to directly apply the knowledge they gained. Additionally, it was decided to administer pre-tests at the beginning and post-tests at the end of the activities to assess the development of teachers' knowledge and skills. Organizational tasks such as organizing the activities and providing materials and resources were carried out by the researchers. The process of data collection and analysis was also conducted by the researchers. Additionally, researchers provided education and guidance to the teachers during the

activities and maintained continuous communication with them throughout the study process.

Data Analysis

SPSS 23 software package was used for the analysis of quantitative data collected during the study. To determine whether there were any gender-based differences in teachers' attitudes towards technology use before and after the study, and to assess the normality of the data distribution, skewness and kurtosis coefficients were examined to see if they fell between -1 and +1. Additionally, due to the small size of the study group, the Shapiro-Wilk test was employed for analysis (Buyukozturk, 2017; Cevahir, 2020). The presence and impact of outliers in the data were assessed, and their effects on the analysis were considered and managed appropriately. Additionally, the adequacy of the sample sizes for both groups (woman and man) and the equality of group sizes were checked. The independence of data within each group was also examined to ensure that individual responses did not influence each other. Following a detailed examination of these parameters, the Mann-Whitney U test was employed for analyzing the scale data. This test is used to determine whether two different groups have similar distributions regarding the variable under investigation. Particularly in experimental studies with a small number of subjects, this test is frequently preferred for data that do not meet the normality assumption.

In the study, content analysis was used for the analysis of qualitative data. Content analysis involves breaking down data into smaller units and categorizing these units. In this process, the researchers used the terms content analysis and coding synonymously, providing an objective, structured, and quantitative explanation of symbolic behaviors, which ensured the attainment of repeatable and valid results (Cartwright, 1953). The journals were reviewed several times by the researchers, and codes were created based on the identified concepts. After compiling and examining these codes, themes were developed by considering the commonalities and similarities among the codes. For example, based on the teachers' responses to the question “What technological skills did you acquire in the project?”, conceptual codes such as “learning and applying technological practices, reinforcing knowledge through practical application” and “understanding the mechanisms of robots and learning the fundamental principles of mechanical systems” were identified. The common points among the codes were analyzed to create final themes, and the general trends of the data were determined through these themes. This process was carried out independently by two researchers, and a comparative review was conducted to ensure consistency in the obtained results. During this process, the following important concepts were considered to evaluate the validity and reliability of the journals:

- Researchers assured teachers of the confidentiality of their journals, directed them to express their opinions, and experiences clearly and openly with explicit and clear questions, and ensured that the contents were analyzed without disclosing their personal information.
- Teachers were encouraged to use clear and understandable language in their journals to increase the transferability of the data. They were provided with guidance and questions to provide information under specific topics or headings in their journals, and the data were described in detail and presented impartially.

- Data consistency was evaluated using the Miles-Huberman formula, aiming for an agreement of 80% or higher among coders (Miles & Huberman, 1994; Patton, 2002). The obtained agreement value was calculated as 85%.
- For the validity and reliability of the study, the data were verified by an expert group, aiming to enhance the validity and reliability of the study (Cepni, 2011; Denzin & Lincoln, 1994). Additionally, direct quotations have been included to support validity.

Results

In this section, the results obtained from the journals kept by the teachers to share their own opinions, and experiences based on their attitudes towards technology use in education, as well as the conducted activities and observations, are presented.

Teachers' Attitudes towards Technology Use in Education

The results of the Mann-Whitney U test comparing teachers' attitudes towards technology use in education before and after the application, based on gender, are presented in Table 2.

Table 2

Mann-Whitney U Test Results for Attitudes towards Technology Use in Education by Gender

Variables	Gender	Number of People (N)	Rank Mean	Sum of Ranks	U	p
Attitude towards Technology Use in Education Scale_Pre	Woman	16	14.66	234.50	98.50	.57
	Men	14	16.46	230.50		
Attitude towards Technology Use in Education Scale_Post	Woman	16	13.47	215.50	79.50	.16
	Man	14	17.82	249.50		

Upon examining Table 2, the U statistic for the “Attitude towards Technology Use in Education Scale_Pre” between women and men is 98.50, with a p-value of 0.57. Thus, no statistically significant difference was found between genders in this measurement ($p > 0.05$). In the case of the “Attitude towards Technology Use in Education Scale_Post”, the U statistic between women and men is 79.50, with a p-value of 0.16. Similarly, no statistically significant difference was found between genders in this measurement as well ($p > 0.05$). Consequently, when the data is examined based on gender, no statistically significant difference in attitudes towards technology use is observed between women and men.

Teachers' Journals

In this section, the questions in teachers' journals, the responses to these questions, the themes and codes generated, the frequencies of these responses and codes, and some students' opinions are presented.

Various skills gained by teachers during the course of the study through the conducted activities are provided in Table 3.

Table 3

Activities and Gained Skills

Days	Activities	Skills		
		Learning and Innovation Skills (creativity and innovation, critical thinking, problem-solving, communication, collaboration)	Information, Media, and Technology Skills (information literacy, media literacy, information and communication technology literacy)	Life and Career Skills (flexibility and adaptability, entrepreneurship and self-direction, social and intercultural skills, productivity, leadership)
1st day	Characteristics of gifted children and their educational needs	9	6	15
	STEAM theory and practices	13	10	15
	Introduction to robotics through Milo Science	8	5	17
	The fastest racing car	12	8	15
2nd day	Solar-powered car	14	6	12
	Designing my dreams with a 3D pen	13	12	14
	My dream car	10	5	13
	Earthquake simulator	7	7	12
	Researcher teachers building a theme park I	14	10	13
	Researcher teachers building a theme park II	12	9	12
3rd day	Augmented reality activity with Aurasma	19	16	24
	Augmented reality activity with Quiver Education app	20	16	21
	Smart projects with Arduino	20	16	24

	Preparing interactive exams with Kahoot! app	20	18	21
	Preparing interactive exams with Powtoon app	22	20	18
	My paper fan-powered car	17	12	14

Table 3 shows that the skills gained by teachers from the activities increased as the study progressed. Especially the activities on the 3rd day (Augmented reality activity with Aurasma, augmented reality activity with Quiver Education app, smart projects with Arduino, preparing interactive exams with Kahoot! app, preparing interactive exams with Powtoon app, my paper fan-powered car) have provided teachers with a wide range of skills. Additionally, it is observed that teachers made progress, particularly in the "life and career skills" domain as a result of these activities.

The frequencies of the responses given by teachers to the question "What did you learn technologically in the project?" are presented in Table 4.

Table 4

Responses of Teachers Regarding their Technological Learning Experiences

Days	Themes	Codes	f
1st day	Technological development and application skills	Learning and using technological practices, reinforcing knowledge by practical application	10
		Understanding the working mechanism of robots and learning the basic principles of mechanical systems	4
		Learning the importance of technology for life, understanding the role of technology at individual and societal levels	2
		Using algorithms in vehicle construction with Legos and making connections with daily life	1
		Learning basic technology concepts and acquiring basic knowledge in information technology, hardware, and software	1
		Learning how new technological designs can be made with creative thinking skills	1
		Realizing the convenience of robotics and coding in many areas of life, understanding the universal importance of these skills	1
		Recognizing the efficiency of learning by doing rather than theoretical knowledge in technological practices	1
2nd day	STEAM education and technological skills	Developing skills related to the use of 3D pens	9
		Learning about renewable energy concepts using solar panels and simple motors	9
		Acquiring the ability to use WeDo 2.0 program	5
		Learning design and coding practices using Lego	3
		Gaining the ability to use the Green Screen practice	3
		Understanding the STEAM concept and learning process within	3

		this scope	
3rd day	Variety and use of technological concepts in STEAM education	Understanding the features and usage areas of practices like Aurasma, Kahoot!, Powtoon	12
		Grasping the basic coding principles used in robotic systems	2
		Understanding the principles and operation of 3D technological devices	1
		Learning the design processes of STEAM activities	1

In Table 4, responses of teachers regarding their technological learning experiences during the three-day projectare provided. On the first day, teachers learned basic technology concepts, including the working mechanisms of robots, their fundamental principles, and the use of algorithms in Lego vehicle construction. They also had the opportunity to understand the individual and societal role of technology in life. On the second day, they focused on various topics such as 3D pen usage, renewable energy concepts with solar panels and simple motors, the WeDo 2.0 program, Lego design, and the Green Screen application. On the third day, their focus shifted to features of practices like Aurasma, Kahoot!, Powtoon, coding principles used in robotic systems, usage of 3D technological devices, and STEAM activity design processes. Some of the responses to the question are provided below:

> Teacher Efe: I learned that by closely following technology, many projects can be produced, and it's essential to keep up with the rapid developments in technology.
>
> Teacher Idil: I was not knowledgeable about online practices like Canva, Kahoot!, Powtoon, etc. I gained awareness about them. I will use them in my lessons to both raise awareness among my students and make the lessons enjoyable and productive.

The frequencies of responses given by teachers to the question “What are your strengths in terms of technology?” are provided in Table 5.

Table 5

“Responses Regarding “Creative Technology Skills and Openness to Development” Theme

Days	Responses	f
1st day	Ability to creatively combine mechanical knowledge to generate innovative solutions	1
	Capability to quickly and easily adapt to new programs and technological developments	1
2nd day	Possessing creative thinking skills in a technological context	1
	Being open to technological advancements	1
	Applying critical thinking skills in a technological context	1
3rd day	Having an openness to learning in a technological context, being curious, and having a willingness for continuous development	5
	Possessing innovative thinking skills and a sense of responsibility while using technology	2
	Ability to quickly grasp and learn technological information	1

Table 5 summarizes the responses of teachers under the theme of "creative technology skills and openness to development". On the first day, teachers highlighted their abilities to creatively combine mechanical knowledge to generate innovative solutions and to quickly adapt to new programs; both responses came from a single teacher. On the second day, teachers emphasized their creative thinking skills in a technological context, openness to technological advancements, and application of critical thinking skills; each of these three responses came from different teachers. On the third day, teachers focused on openness to learning in a technological context, curiosity, and willingness for continuous development; these responses were provided by five teachers. Additionally, two teachers discussed innovative thinking skills and a sense of responsibility while using technology. The ability to quickly grasp technological information was mentioned by only one teacher. In the evaluation of the 30 teachers, the majority of responses did not align with the examined skill, and only a limited number of teachers' responses were consistent with this theme. Therefore, the views of the other teachers were not considered under this theme. Some of the responses to the question are provided below:

> Teacher Ali: I believe I am fast in grasping and learning technological information.
>
> Teacher Sevda: I realized that I am open to learning in a technological context and can adapt quickly.

The frequencies of the responses given by teachers to the question "What are your shortcomings in terms of technology?" are provided in Table 6.

Table 6

Responses Regarding "Deficiencies in Technological Skills and Development Needs" Theme

Days	Responses	f
1st day	Not having sufficient skills in coding	1
	Not having adequate interest and knowledge in engineering discipline where new designs generally attract attention	1
	Feeling inadequate in integrating technology into the curriculum successfully	1
	Feeling deficient in STEAM subjects	1
2nd day	Feeling deficient in engineering and design disciplines	2
	Feeling deficient in coding	1
	Having a lack of understanding of technological concepts	1
3rd day	Being inadequate in keeping up with technology trends	1
	Feeling deficient in coding skills	1

Table 6 summarizes the teachers' responses to the theme of "deficiencies in technological skills and development needs" by day and number of teachers. On the first day, it is observed that teachers highlighted various technological skill deficiencies. Four teachers indicated their lack of proficiency in coding, lack of interest and knowledge in engineering disciplines related to new designs, difficulties in successfully integrating technology into the curriculum, and inadequacies in STEAM subjects. Each

response came from a different teacher. On the second day, deficiencies in engineering and design disciplines and coding skills were emphasized. On this day, two teachers mentioned deficiencies in engineering and design disciplines, while one teacher noted inadequacies in coding and technological concept understanding. On the third day, teachers pointed out deficiencies in keeping technology up-to-date and in coding skills. On this day, one teacher mentioned issues with staying current with technology and another with coding skills. Given that many responses did not align with the examined skill and only a limited number of teachers' responses were consistent with this theme, the views of the other teachers were not considered within this theme in the evaluation of 30 teachers. Some of the responses to the question are provided below:

> Teacher Merve: I believe I have a lack of understanding of concepts and a knowledge gap in the fields of science and engineering.
>
> Teacher Selim: I think I have many deficiencies. I especially realized the need to closely follow technology.

Discussion and Conclusion

The aim of this study was to determine how innovative practices designed for the educational needs of gifted children, taught in activities within the scope of the TUBITAK 4005 “Journey to Innovative Practices of Science with Support Education Room Teachers” project, affected teachers' attitudes and opinions towards the use of technology in education.

Research on technology use indicates that there are differences in technology use and attitudes between men and women. These differences are associated with demographic characteristics such as gender, ethnicity, religion, social, and economic status (Anandhita & Ariansyah., 2018; Oldeweme et al., 2021; Rahiem, 2020; Wilhelm, 2018). These demographic factors influence individuals' attitudes towards technology. There are various approaches in the literature regarding how technology use changes according to gender (Ardies et al., 2015; Plumm, 2008; Teo et al., 2016). In particular, signs of differences in technology use between genders still exist in education (Tasci et al., 2023). However, the results of the Mann-Whitney U test analysis conducted in this study indicate that there was no statistically significant difference between man and woman teachers' attitudes towards technology before and after the implementation (Table 2). This result suggests that innovative practices supporting the use of technology in education may be beneficial for all teachers regardless of gender. This result is consistent with many studies in the literature (Ardic, 2021; Dursun et al., 2017; Qazi et al., 2022), highlighting that technology use is influenced not only by gender but also by demographic, social, and cultural factors. Therefore, these factors are critical in effective technology use in education.

The continuous updating of skills and competencies for both students and teachers enhances the role of technology in education (Gulcu et al., 2013). The results of this study indicate that the educational activities provided to teachers help to improve their learning and innovation skills, media and technology knowledge, as well as life and career skills. The literature suggests that innovative practices equip teachers with problem-solving, creativity, and collaboration skills, and also enhance life and career skills (Sayin, 2020; Avci et al., 2019). Technological tools offer significant opportunities for students, such as reducing peer pressure, increasing creativity, and

improving mathematical skills. Additionally, interaction with technology enhances communication and supports collaboration and teamwork skills. Gifted children can achieve more effective learning experiences through the use of information technology (BECTA, 2001). Therefore, the role of technology in education is a critical factor that enriches and develops the educational processes for both students and teachers. Throughout the study, the activities provided to teachers have developed their learning and innovation skills, media and technology knowledge, as well as life and career skills. Particularly, activities conducted on the third day offered a broad range of skills and showed a notable development in "life and career skills" (Table 3). STEAM theories and practices, robotics, augmented reality, coding, and interactive exam preparation were observed to significantly contribute to the professional development of teachers. Teachers acquired various new information and skills in STEAM education and technological development, including robotics, 3D technology, coding, augmented reality, solar energy, and media literacy. Notably, in the later days of the study, an increased interest in technological concepts, practices, and STEAM education among teachers was observed (Table 4). Furthermore, teachers emphasized skills such as creative technological thinking, openness to technological advancements, critical thinking, and openness to continuous learning, showing development in these areas (Table 5). These results suggest that innovative educational activities can enrich teachers' technological learning experiences and contribute to the continuous updating of their technological skills and competencies.

Evaluations conducted throughout the study revealed that teachers felt inadequate in keeping up with current technology, particularly in coding, engineering, design, and STEAM subjects (Table 6). These inadequacies manifest as gaps in teachers' abilities to integrate technology into the curriculum and in their knowledge and skills regarding fundamental technology concepts. This situation is supported by several studies, which highlight that support staff and subject teachers often lack sufficient professional knowledge and experience, leading to challenges in educating students with special needs (Fazlioglu & Dogan, 2013; Kartopu, 2013; Pektas, 2008). These gaps in teachers' competencies can hinder their ability to provide effective and high-quality education, potentially negatively impacting students' learning processes. Therefore, it is essential to continuously update technological skills and competencies, invest in teachers' professional development, and provide more comprehensive and ongoing support for technology education. Innovative educational activities and programs play a critical role in enhancing teachers' professional knowledge and experience, ensuring effective use of technology, and providing students with more effective learning experiences.

Implications

Based on the results of this study, the following recommendations can be made for teachers and gifted children:

- It is recommended to prepare specialized educational materials and resources to enable teachers to enhance their skills and competencies in using technology in education.
- Regular professional development programs, training sessions, and seminars should be conducted to allow teachers to keep their technological knowledge

and skills current and address deficiencies in areas such as coding, engineering, and design.

- Interactive and hands-on learning opportunities should be provided to students.
- Personalized educational programs should be developed for gifted children, tailored to their individual interests and abilities.

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Statement of Responsibility

All sections of the article have been collectively written by the authors. Introduction, method, results, discussion and conclusion sections have been collaboratively composed.

Conflicts of Interest

The authors or the article do not have any financial, commercial, legal, or professional relationship with any person or organization, therefore, there is no conflict of interest.

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A Review on Personalization of Gamified Learning Environments*

Oyunlaştırılmış Öğrenme Ortamlarının Kişiselleştirilmesi Üzerine Bir Derleme

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ABSTRACT: This study explores the personalization of gamification in educational contexts, particularly adaptive approaches to meet diverse learner needs. The study examines terminologies and offer definitions for adaptive, tailored, personalized, and customized gamification. Personalization serves as an umbrella term covering any changes in the process. Customization is the changes performed by the user/learner; tailored gamification involves adjustments made at the beginning and adaptive gamification involves system-driven changes as things progress. The analysis of adaptive gamification studies is structured around adaptation criteria, adaptation process, adaptation data, and adaptive intervention. Adaptation criteria include player types, personality models, learning styles, and hybrid profiles. Adaptation process includes user-controlled and system-controlled adaptation. User-controlled adaptation refers to customization; system-controlled adaptation is examined under static adaptation, dynamic adaptation, and combination of these two. Adaptation data is categorized under explicit and implicit information collection. Lastly, recommendations, and adjusting game elements and mechanics are discussed under adaptation intervention. The review highlights the commonly used player typologies, including Bartle, Hexad, and BrainHex, and personality models such as Big Five and Myers-Briggs Type Indicator. The review identifies limitations in current frameworks, stressing the importance of standardized models and guidelines to implement adaptive gamification and incorporating gamification analytics to sustain adaptation and automation.

Keywords: Adaptive gamification, tailored gamification, customization, personalization.

ÖZ: Bu çalışma kişiselleştirilmiş oyunlaştırmanın eğitsel bağlamlardaki kullanımını, özellikle de oyunlaştırmanın farklı öğrenen ihtiyaçlarına yönelik uyarlanmasındaki yaklaşımlar açısından incelemektedir. Çalışma bu bağlamda kullanılan uyarlanmış, uyarlanabilir, kişiselleştirilmiş ve özelleştirilmiş oyunlaştırma terimlerini inceleyerek bu terimlere ilişkin tanımlar ortaya koymuştur. Kişiselleştirilmiş oyunlaştırma, oyunlaştırma sürecindeki herhangi bir değişikliği tanımlayan şemsiye kavramdır. Uyarlanmış oyunlaştırma, uygulamanın başlangıcında yapılan değişikliklerdir. Uyarlanabilir oyunlaştırma, sistem tarafından uygulama sırasında dinamik olarak yapılan değişikliklerdir. Özelleştirme, oyunlaştırma sürecinde kullanıcı/öğrenci tarafından yapılan değişiklikleri ifade eder. Uyarlanmış oyunlaştırma çalışmaları dört başlıkta incelenmiştir: uyarlama kriterleri, uyarlama süreci, uyarlama verisi ve uyarlama müdahalesi. Uyarlama kriterleri, oyuncu tipleri, kişilik modelleri, öğrenme stilleri ve karma profilleri içermektedir. Uyarlama süreci, kullanıcı-kontrollü ve sistem-kontrollü uyarlamayı içerir. Kullanıcı-kontrollü uyarlama, özelleştirmeyi ifade etmekte, sistem-kontrollü uyarlama ise statik uyarlama, dinamik uyarlama ve bu ikisinin kombinasyonu olan dinamik+statik uyarlama altında incelenmektedir. Uyarlama verileri, açık ve dolaylı bilgi toplama yöntemleri olarak iki kategoriye ayrılmaktadır. Son olarak, öneriler ve oyun bileşen ve mekaniklerinin uyarlanması, uyarlama müdahalesi altında ele alınmıştır. Çalışma, Bartle, Hexad ve BrainHex gibi oyuncu tiplerinin ve Beş Faktör ve Myers-Briggs gibi kişilik modellerinin uyarlama çalışmalarında sıklıkla kullanıldığını göstermektedir. Çalışma ayrıca mevcut çerçevelerdeki sınırlılıkları, oyunlaştırmanın nasıl uyarlanacağını gösteren standartlaştırılmış modellerin önemini ve uyarlamanın otomatikleştirilmesi ve sürdürülebilir olması için oyunlaştırma analitiğinin entegrasyonunu vurgulamaktadır.

Anahtar kelimeler: Uyarlanabilir oyunlaştırma, uyarlanmış oyunlaştırma, özelleştirme, kişiselleştirme.

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Gamification has been becoming a widely common trend in recent years. Simply put, it can be defined as using game elements in non-game environments (Deterding et al., 2011). It can also be explained as the act of turning a non-game environment, an application, or a process into a game through some game-specific mechanics or principles and making people feel like they are playing a game. Most of the applications or systems in our daily lives are gamified. Although the notion of turning something into a game has been prevalent over the long-term in domains such as marketing, "gamification" has emerged as a term in the 2010s (Nacke & Deterding, 2017). In the educational context, Kocadere and Çağlar (2018) defined gamification as an approach that involves incorporating game design elements to facilitate learners' participation, motivation and curiosity.

Game design elements have been structured differently by different researchers. The most well-known frameworks are the MDA framework (mechanics-dynamics-aesthetics) by Hunicke et al. (2004), Zichermann and Cunningham (2011); and dynamics - mechanics - elements by Werbach and Hunter (2012). These structures are often represented in a pyramid shape, in an order of abstraction. So, dynamics and aesthetics are the most abstract of these components. According to Hunicke et al. (2004) (p.2) aesthetics refers to the "desirable emotional responses" evoked in the player during interaction with the game system. Mechanics are the rules and rewards aiming to evoke certain emotions in learners; elements are the items that serve the mechanics and can be observed in the gamification design (Simões et al., 2013; Werbach & Hunter, 2012). Although many studies commonly use the aforementioned tripartite structures in many studies, some researchers (Bicen & Kocakoyun, 2018; Iosup & Epema, 2014; Karayiğit et al., 2022; Kocadere & Çağlar, 2018) prefer bipartite structures. In fact, Karayiğit et al. (2022), mentioned that there are no strict lines between the three categories and some components can act as an element or a mechanic depending on the context. To illustrate, a trophy in a gamification design can be considered as a reward component; however, in cases where there is no direct reward and the badges earned by the player are considered as rewards, the reward can be thought of as a mechanic (Karayiğit et al., 2022). Furthermore, the terminologies to define these elements may differ as well (Klock et al., 2020). Frequently employed elements and mechanics in gamification designs include point, badge, level, achievements, trophies, rankings, progress bar, virtual goods, leaderboard, gift, quest, team, avatar as elements; reward, progression, competition, narrative, altruism, feedback, challenge and status as mechanics (Antonaci et al., 2019; Zainuddin et al., 2020).

Based on the definitions, gamification aims to improve students' experience in terms of motivation, engagement, and academic performance by integrating game design elements into learning environments. Multiple studies have shown that gamification has positive effects on these aspects (Bai et al., 2021; Çağlar Özhan & Arkün Kocadere, 2020; Gironella, 2023; Zainuddin et al., 2020). Findings suggest that it enhances students' motivation by giving them instant feedback (Boverman et al., 2018), allowing them to keep track of their progress (Boverman et al., 2018; Li & Chu, 2021), rewarding for their actions (Domínguez et al., 2013), and increasing collaboration (Knutas et al., 2016; Li et al., 2013) or fostering a competitive atmosphere (Bai et al., 2021; Pilkington, 2018). By improving students' engagement and motivation, it affects students' achievement in a positive way (Çağlar Özhan & Arkün Kocadere, 2020;

Çakıroğlu et al., 2017; Pechenkina et al., 2017; Su & Cheng, 2015; Yu et al., 2023). However, the impact of gamification is not always positive; several studies have reported adverse outcomes or no outcomes at all. Elements that yield positive effects in certain cases may exhibit no effect or even result in negative outcomes in others (Hanus & Fox, 2015; Kwon & Özpolat, 2021; Kyewski & Krämer, 2018). One of the underlying reasons could be the fact that individuals are influenced by the diverse game design elements or mechanics (Hassan et al., 2021; Kocadere & Çağlar, 2018; Orji et al., 2018). In a systematic review by Ertan and Arkün Kocadere (2022), the significance of individual differences has emerged as a crucial finding of the study. As proposed by different studies, it is significant to design learning environments to accommodate diverse student needs and abilities and captivate their attention (Çağlar Özhan & Arkün Kocadere, 2020; Hassan et al., 2021). Considering individual differences of students results in effective and permanent learning (Şimşek, 2002), and also increased motivation and success (Erdoğdu, 2020). Hassan et al. (2021) argue that instead of offering the same experience to each student, gamification design should be tailored according to different learners. Their study reveals the positive effects of tailored gamification on students.

Based on the idea that traditional online learning environments often present similar content and structures to all students, which may lead to information density for users, adaptive learning systems have gained prominence (Eryılmaz & Şimşek, 2014). In this context, it can be seen that gamification studies have been trending in a similar direction in recent years with a notable emphasis on adaptive gamification. Adaptive gamification is based on the notion that different individuals' having different expectations, interests and personalities (Oliveira & Bittencourt, 2019) make difference in the way they react to game mechanics (Monterrat et al., 2015; Santos et al., 2021). Kocadere and Çağlar (2018) studied the preferences of learners with different player types and they included different game elements suited to all player types in their design to meet different expectations of learners. Monterrat et al. (2015) stated considering all player types within a single design would create an excessive load on the interface; therefore, they emphasized the need for a personalized gamification. In order to increase the efficiency of gamified systems, several models were developed that considered player types, personality traits, and motivation profiles (Tondello et al., 2016).

In regard to the idea that gamified environments should consider different learning styles, player profiles, individual differences and employ a "one size does not fit all" approach (Monterrat et al., 2015), concepts such as tailored gamification, adaptive gamification, personalized gamification and customized gamification emerged in the literature. These concepts share a common underlying principle, reflecting a change of strategy to suit individual needs or preferences (Klock et al., 2020).

In terms of tailored and adaptive gamification, researchers often use the terms "tailoring" and "adapting" interchangeably. The general idea of tailoring or adapting a gamified environment involves designing gamification by considering learner needs, preferences, and characteristics (Oliveira & Bittencourt, 2019). While the concepts of tailoring and adapting do not have strict boundaries between them, tailoring typically starts with creating a profile and builds adaptations from there (Klock et al., 2020; Kreuter et al., 2000). Adaptations can happen in real-time, in other words, a dynamic adaptation, or it can be a static adaptation (Hallifax et al., 2020). In a static system, the

adaptation happens just once, typically before learners begin using the learning platform. On the other hand, in a dynamic system, modification occurs multiple times while learners are engaging in their learning activities (Hallifax et al., 2019a). From this point of view, it can be said that while tailored gamification is associated with static adaptation, adaptive gamification aligns with dynamic adaptation. In the literature, there are also some studies that involve combined use of dynamic and static adaptation (Hallifax et al., 2021; Monterrat et al., 2015).

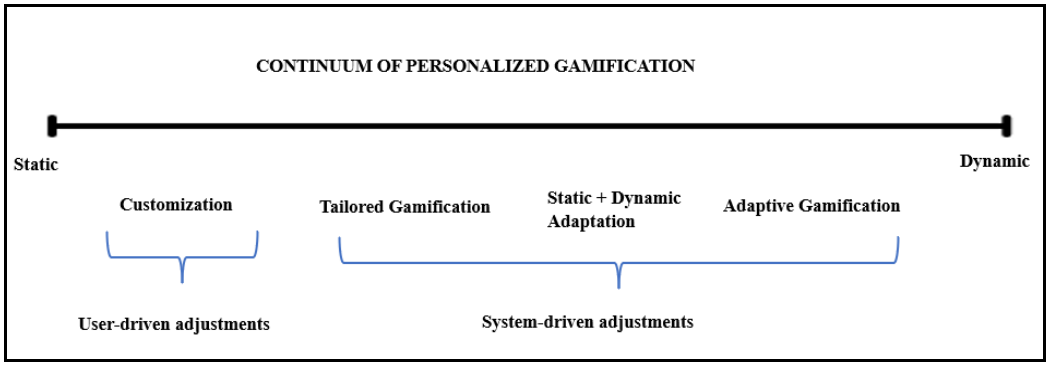
According to Oliveira and Bittencourt (2019), personalization refers to minor adjustments in the system such as changing the color of the game design elements based on the country or the time that the system is being used; on the other hand, tailored gamification implies modifications that go deeper and reach a higher level of complexity. These modifications are made on the basis of individual differences including learner typologies, player types, age and/or gender. Regarding customization, users have the opportunity to make changes in the system interface. For instance, the act of selecting an avatar for self-representation exemplifies this customized touch (Oliveira & Bittencourt, 2019). Sundar and Marathe (2010) explain the difference between customization and personalization, stating that personalization involves system-tailored adjustments while customization involves user-tailored adjustments. In this study, the definitions we provided are as follows:

- Personalized gamification serves as an umbrella term describing any changes in the gamification process.
- Customized gamification refers to the changes made by the user/learner during the gamification process.
- Tailored gamification includes changes made at the beginning of the process, based on data about the learners.
- Adaptive gamification includes dynamic changes made by the system throughout the process, based on data about the learners.

In Figure 1, the connection between these different terms in this context was visualized by the authors based on their own findings and interpretations derived from the literature.

Figure 1

Continuum of Personalized Gamification



Although the distinction between the terms used in adaptation context is less evident within the field of gamification, it becomes more pronounced when it comes to adaptive systems. Researchers (Brusilovsky et al., 1995; Oppermann, 1994) state that adaptive systems are the ones that employ collected information about the user to dynamically adjust their behavior, aiming to provide personalized experiences and content. There is also a distinction between adaptive and adaptable systems. Adaptable systems refer to the systems offering a degree of flexibility enabling users to customize certain features of the system according to their preferences or needs (Brusilovsky et al., 1995; Oppermann, 1994). Typically, computer-based teaching systems that enable users to select specific settings and modify the system's behavior are commonly known as learner-controlled instruction or adaptable systems. In contrast, adaptive systems, also known as program-controlled (system-controlled) instruction, automatically tailor their behaviors based on the user's needs (Lee & Park, 2008).

This study aims to explore and analyze different methods of adapting gamified learning environments, including the mechanisms and criteria used in adaptive gamification. In addition to explaining various terms in this context, it seeks to shed light on how tailored, adaptive, personalized, and customized gamification strategies are designed, implemented, and influence learning outcomes in educational settings. There is currently no consensus on these terms, leading to confusion in both research and practical applications. By defining these terms clearly, our study aims to provide a solid foundation for understanding and advancing adaptive gamification. Adaptive gamification offers promising opportunities to enhance engagement, motivation, and learning outcomes by catering to individual learner needs. This research addresses a gap in understanding by examining diverse approaches to adaptive gamification and their practical effects in educational contexts. By providing insights into effective design and implementation strategies, the study aims to contribute to optimization of gamified learning environments.

Method

This study adopts a literature review methodology to offer a comprehensive and insightful overview of the concept of adaptive gamification. Literature reviews or in other words review articles offer many possibilities to contribute to theory, progress our understanding of principles about a specific topic (Post et al., 2020) and provide a summary of current information, enabling the recognition of particular research theories, methodologies, and identifying gaps in the literature (Bennani et al., 2022). Given that strict inclusion/exclusion criteria limit the scope and may lead to relevant studies being overlooked, a systematic approach was deliberately avoided in this review. This allowed for a broad exploration of the topic using a variety of sources, which is very important in an emerging field such as adaptive gamification.

Adapting Gamified Learning Environments

Adapting educational experiences to individual needs and preferences within gamified settings has emerged as a critical domain aiming to increase motivation and enhance overall educational outcomes. However, a complete framework that defines the principles behind adaptive gamification solutions is missing and such a framework is crucial to outline the objectives of adaptive gamification elements (Böckle et al., 2018).

In terms of adaptive methods in educational hypermedia, the framework by Specht and Burgos (2007) was structured according to four main questions: (1) "What components of the educational system are adapted?" (2) "To what features of the user and the current context does the system adapt?" (3) "Why does the system adapt?" (4) "How does the system get the necessary information?" (p. 1). Böckle et al. (2018) proposed a design framework, inspired by Specht and Burgos's (2007) questions, which consists of four categories: "(1) Purpose of Adaptivity, (2) Adaptivity Criteria, (3) The Adaptive Game Mechanics & Dynamics, and (4) Adaptive Interventions" (pp. 1229–1230). Although two of the categories partly match (adaptivity criteria matches with *to what features of the user and the current context does the system adapt* and *purpose of adaptivity* matches with *why does the system adapt*), Böckle et al. (2018) extends it to address the specific aspects related to gamification. The details are as follows (Böckle et al., 2018):

- Purpose of adaptivity includes several reasons for adaptation such as changing the state of the user, which refers to modifying the end-user's attitude towards their goals, motivation, and beliefs, aligning them with the advantages of utilizing the system, supporting learners in the learning process, supporting active participation, and establishing a meaningful connection between the non-game context and the objectives of the end-users.
- Adaptivity criteria refers to the basis that the adaptation process builds on. It includes player type/personality type, usage/user-data, context, level of knowledge, defined goals by the user and reputation/status (p.1230).
- Adaptive game mechanics and dynamic include feedback, level difficulty, points and competition/customized challenges (p. 1230).
- Adaptive intervention is about gamification elements that show the outcomes of the adaptation process within the user interface. The most common intervention is giving suggestions and recommendations to let users know about their learning progress, like reminding them of upcoming deadlines or giving personal feedback. Adaptive intervention also includes a customized learning experience by adjusting the learning path to the user's existing skills or accomplishments, or by offering multiple paths to the same goal.

Codish and Ravid (2014) suggest a framework that includes gamification analytics to monitor how individuals perceive playfulness and engagement in specific contexts, which aims to establish usage patterns and adjust system rules accordingly. Similarly, the emphasis on using analytics to personalize feedback in gamified learning environments was exemplified in the study by Bayrak et al. (2021). Böckle et al. (2018) state that the user information sub element under adaptivity criteria in their framework was informed by the Codish and Ravid's (2014) framework. Therefore, the framework mentioned here is limited in the way that can correspond only to the adaptation criteria from Böckle's classification.

In this section, we will focus on how gamified learning environments can change to suit each person's needs. Taking prior studies into consideration, a structure has been established for this study. While establishing our structure, we drew inspiration from Böckle et al.'s (2018) design framework, which was influenced by Specht and Burgos's

(2007) questions. We will discuss adaptive gamification through the following structure consisting of four main elements (Table 1):

(1) *Adaptation criteria* serve as the basis for determining how adaptations will be implemented. It includes the information that will be used by the system for adaptation such as player types, personality models and learning styles.

(2) *Adaptation process* focuses on outlining how the adjustment will take place and includes dynamic and static adaptation.

(3) *Adaptation data* is about information collection methods about the learners.

(4) *Adaptation intervention* is the stage where practical steps of adaptation occur. It mainly includes recommendations, giving personalized feedback, and adapting gamification design elements and mechanics.

Table 1

Adaptive Gamification Structure

Adaptation criteria	Adaptation process	Adaptation data	Adaptation intervention
● Player Type ○ BrainHex ○ Hexad ○ Bartle ● Personality Models ○ Myers-Briggs Type Indicator ○ Five Factor model ● Learning Style ○ Felder-Silverman ● Hybrid Models	● User controlled ● System controlled ○ Static adaptation ○ Dynamic adaptation ○ Static+Dynamic adaptation	● Explicit information collection ○ Self-reports ○ Self-assessments ○ Responses to test items ○ Knowledge assessments ○ Questionnaires ○ Scales ● Implicit information collection ○ System logs/interactions ○ Sensor-based information	● Recommendation ● Personalized feedback ● Adapting game mechanics and elements

Adaptation Criteria

This section focuses on the elements that form the basis of adaptation. Researchers based their adaptation on several elements including player types, personality models, learning styles and hybrid profiles.

Player Types

In adaptations based on player type, Bartle, BrainHex and Hexad player typologies are frequently preferred.

In Bartle's (1996) classification for multi-user virtual worlds, players are categorized into four groups as achievers, explorers, socializers, and killers. Accordingly;

- *Achievers* enjoy acting in the game world and play to win.
- *Explorers* enjoy interacting with the game world and like to explore.
- *Socializers* enjoy interacting with the other players and spend their time chatting.
- *Killers* enjoy acting on other players and like to dominate them through bullying or strategic behaviors.

In the study conducted by Kocadere and Çağlar (2018), Bartle's player types were chosen to investigate the relationship between player types, game components, and mechanics. The study revealed that the mechanics and components that influence learners vary based on their player types. Furthermore, the game components triggering specific mechanics show differences according to player types, subsequently impacting the entire design process. Meanwhile, researchers examining whether learners' flow experiences differ based on player types and gender did not find a significant distinction in the flow experiences among different player types and genders (Marinho et al., 2019).

Kırmacı and Çakmak (2024) developed an Online Gamified Learning Environment and examined the impact of these environments on learners' engagement, motivation, and participation. In the experimental group of the study, students were presented with scenarios tailored according to Bartle player types, while students in the control group participated in an Online Learning Environment without gamification elements. Although there was no significant difference in terms of engagement and motivation scores between the experimental and control groups, it was observed that learners' participation and interaction increased in the experimental group.

Considering Bartle's classifications are specific to Multi-User Dungeons (MUDs) and should not be extended to other game genres or gamified designs, Marczewski (2015) developed a gamification-specific framework called Hexad. The framework is grounded in human motivation, player types and practical design experiences. The player types and the motivating factors for them explained by Hexad can be summarized as follows:

Philanthropists are motivated by a goal. They have an altruistic nature and are willing to give without any expectation of reward.

Socializers are motivated by being related. They like to interact with others and build social bonds.

Free Spirits find motivation in the freedom of self-expression and acting without external control, known as autonomy.

Achievers are motivated by competence. They aim to progress by completing the tasks within a system and to prove that they can overcome tough challenges.

Players find motivation in external rewards. They are willing to do whatever it takes, regardless of the activity, to earn a prize.

Disruptors are motivated by the triggering of a change. While they may tend to directly disrupt the system, they sometimes force others to make positive or negative

changes. They like to test the limits of the system. Disruption is not always negative but can have a positive effect on the development of the system.

The reasons why Hexad is recommended by the researchers are mainly because of the fact that it was developed specifically for gamification and validated (Hallifax et al., 2019b; Knutas et al., 2019; Tondello et al., 2016). The development, validity, and reliability study of the Hexad model and the scale devised to determine user preferences within this model were carried out by Tondello et al. (2016) and game components were suggested for each user type. Additionally, in a study investigating the relationship between various user models and game components to identify the most relevant model for determining users' game component preferences, researchers (Hallifax et al., 2019a; Hallifax et al., 2019b) concluded that Hexad was the most effective model for determining user preferences and its descriptions of user types were consistent. In addition, the application of motivational strategy and the choice of user typology are shown as two major factors affecting motivation in adapted gamification.

Another model that researchers preferred is the BrainHex model developed by Nacke et al. (2014). Building on previous player classifications and neurobiological studies, this model has seven player archetypes: Seeker, Survivor, Daredevil, Mastermind, Conqueror, Socializer, and Achiever. The reason why they were named archetypes was stated by the developers of the model as follows: “Each category within BrainHex should be understood not as a psychometric type, per se, but as an archetype intended to typify a particular player experience, which can thus be understood as a qualitative presentation of an underlying implicit trait framework.” (Nacke et al., 2014, p.58). Here are the summarized details regarding these seven archetypes:

Seeker: These people are motivated by interest mechanisms, are curious about the game world and enjoy these moments of curiosity.

Survivor: People in this archetype enjoy negative emotions such as fear and horror, at least in a fictional context like games and movies.

Daredevil: This group's gaming style is centered around the thrill of pursuing and taking risks, usually playing on the edges.

Mastermind: For the individuals of this archetype, the essence of enjoyment lies in dealing with puzzles that require problem-solving and strategy. They enjoy solving puzzles and developing strategies, as well as focusing on making the most efficient decisions.

Conqueror: Individuals of this archetype are not content with easy victories, want to fight hard until victory, and enjoy beating other players.

Socializer: This archetype includes people whose primary source of entertainment is people, who enjoy talking to people, helping them, and spending time with people they trust.

Achiever: While the Conqueror archetype is challenge-oriented, the Achiever archetype is goal-oriented and motivated by long-term successes. This difference might be subtle, but it is significant. (Nacke et al., 2014)

Lavoue et al. (2019) examined the relationship between BrainHex player types and game elements and revealed that adaptive gamification can significantly enhance the participants of students who use the environment for the longest time, and it can also

reduce students' levels of amotivation compared to non-adaptive gamification. In addition, since the adaptation is more effective on those who spend the most time in the system, the researchers suggested that the elements that keep the participants in the system should be included.

Daghestani et al. (2020) examined whether classifying learners according to their navigation in the system and adapting gamification according to player types increases the effectiveness of e-learning environments. They adapted the design based on BrainHex player types and students were divided into a control group and two experimental groups. While the students in the control group were provided with a non-gamified system, one of the experimental groups with a gamified system and the other one with a gamified system adapted according to player types. The results suggested that gamification had a positive effect on students' engagement and performance, and students exposed to adaptive gamification had better engagement and performance.

Oliveira et al. (2022) investigated whether tailoring gamification according to students' player type had an effect on their flow experience, enjoyment, gamification perception and motivation. Students were divided into seven groups according to BrainHex player types and students in each group were randomly assigned to experimental and control groups. The study was conducted using a within-subject factorial design, and all participants experienced both personalized and non-personalized situations. The study concluded that personalization did not have a significant impact on learners' flow experience, enjoyment, perception of gamification, and motivation. In fact, it was found that the Socializer, Seeker, and Achiever player types enjoyed the non-personalized gamification environment more. Furthermore, the Conqueror and Daredevil player types had more fun in the non-personalized environment, but their perception of gamification was higher in the personalized environment. On the other hand, the Survivors' motivation and perception of gamification was high, but the feeling of enjoyment is the same with the non-personalized environment. According to researchers the reason why the personalized gamification did not yield expected results may be because of low-level personalization, focusing on the dominant player type, using a player typology specific to games, participants' age or gender. Additionally, although the data collection tools are valid and reliable, BrainHex is not a valid tool and spending 30 minutes before responding to surveys may have caused tiredness in students and may not be enough to experience flow (Oliveira et al., 2022).

Personality Models

Another factor considered in the adaptation of gamification is personality models. Based on Carl Jung's psychological types, the Myers-Briggs Personality Indicator has four dimensions: Extraversion-Introversion, Sensing-Intuition, Thinking-Feeling and Judging-Perceiving (Bayırlı et al., 2019; McCrae & Costa, 1989; Zaric et al., 2017). González et al. (2016) proposed a model referred to as gITS (Gamified Intelligent Tutorial System), which integrates artificial intelligence techniques and incorporates game elements, and personalization features. They chose the Myers-Briggs Type Indicator as part of their approach to determine personality types and tailor the gamification experience accordingly.

Additionally, the Big Five Model / Five Factor Model is another model preferred by researchers. As the name implies, this model includes five dimensions: Neuroticism, Extraversion, Openness, Conscientiousness, and Agreeableness (McCrae & Costa, 1989). Each of the five dimensions represents a broad spectrum of traits or tendencies. Neuroticism involves a tendency to experience negative effects such as anxiety, anger, and depression, while extraversion encompasses sociability, activity, dominance, and experiencing positive emotions. Openness is associated with imagination, aesthetic sensitivity, emotional depth, curiosity, and a need for diversity. Agreeableness includes sympathy, trust, cooperation, and altruism. Conscientiousness encompasses organization, perseverance, meticulousness, and a need for achievement (McCrae & Costa, 1989).

Codish and Ravid (2014) focused primarily on extraversion and introversion of the Five Factor Model and concluded that people with different personality traits differ in terms of enjoyment of game elements and perceptions of games. Similarly, Jia et al. (2016) demonstrated that personality traits can influence the acceptance (or rejection) of a gamified implementation depending on the motivational elements used. The study also showed that extroverts tend to be motivated by points, level and leaderboard; individuals with high levels of openness were less likely to find motivation in avatars.

Learning Styles

Another aspect favored in adaptation of gamification is learning styles. Hassan et al. (2021) preferred Felder-Silverman model to adapt an e-learning platform due to its appropriateness for e-learning platforms and established validity and reliability compared to other models. The study investigated the impact of adaptive and non-adaptive gamification on learners' course completion, performance, and motivation, revealing that adapted gamification led to a significant increase in these variables. The Felder-Silverman model categorizes learning styles into four dimensions: (1) Visual-Verbal, (2) Active-Reflective, (3) Sensing-Intuitive, and (4) Sequential-Global. As noted by Felder and Silverman (1988), these four dimensions are not entirely unique or exclusive, as some dimensions align with those found in other well-known models.

Altaie and Jawawi (2021) provided an adapted gamification framework aimed at enhancing information processing skills of children aged 8-13, and their study showed that gamification tailored to Felder-Silverman learning styles not only increased learners' motivation but also raised their willingness to retake quizzes they could not complete, potentially leading to improved performance.

Hybrid Profiles

Although player types are commonly preferred for adapting gamification, some studies have combined player types with personality models, motivation levels, individual preferences, and demographic characteristics.

Hallifax et al. (2020) based their studies on students' motivation profiles in addition to player types. 258 students in a gamified learning environment were assigned a random game element without tailoring, and students’ motivation, player types and engagement metrics were collected while they were using the system. They used the Academic Motivation Scale by Vallerand et al. (1992) to define students’ motivation. The scale addresses motivation in seven sub-dimensions and evaluates intrinsic

motivation, extrinsic motivation and amotivation. These seven dimensions are as follows:

(1) Intrinsic Motivation for Knowledge: Engaging in an activity solely for the joy and fulfillment of experiencing something novel.

(2) Intrinsic Motivation for Accomplishment: Participating in an activity for the delight of overcoming a difficulty.

(3) Intrinsic Motivation Stimulation: Participating in an activity for the sake of enjoyment or excitement.

(4) Extrinsic Motivation External Regulation: Taking part in an activity to get external rewards.

(5) Extrinsic Motivation Introjected Regulation: Engaging in an activity to prevent feelings of shame or enhance self-esteem.

(6) Extrinsic Motivation Identified Regulation: Engaging in an activity to reach specific goals.

(7) Amotivation: Lack of intention to engage in an activity.

After obtaining learner data, three different adaptation simulations were analyzed: (1) Hexad user profile, (2) initial motivation user model, and (3) a combined model called the dual model. For each adapted profile, affinity matrices were created to determine how each profile influenced the preference of game components, and game components were assigned based on each profiles' values on the affinity matrix. A total of 10 lessons were conducted, and after the final lesson, students filled out the motivation scale once again. The difference between the learners' intrinsic motivations, extrinsic motivations, and amotivation before and after the implementation was examined, and it was concluded that dual adaptation increased the learners' intrinsic motivation compared to adaptation based on motivation profiles alone (Hallifax et al., 2020).

Chtouka et al. (2019) aimed to adapt the gamified learning management system with the help of machine learning and created a new Learning Player Profile by presenting a model that combines Felder-Silverman learning styles and BrainHex player types. Based on this new profile, the learning management system has adapted itself according to learner characteristics. Researchers examined the consistency of the system's adaptation with learners' responses to player type and learning style scales and revealed a 77.5% level of consistency. They stated that this approach will optimize the efficiency of adaptation as it allows to adapt learning and gamification at the same time. Details about the eight newly created profiles, formed by considering shared attributes of learning styles and player type models, are as follows:

(1) *The sensing/seeker* prefers gamified learning paths that include tangible materials like exercises and examples.

(2) *The intuitive/mastermind* enjoys challenges and collecting stars, favors a limited number of diagrams and exercises as their main interest lies in learning from abstract materials and solving challenges.

(3) *The visual/survivor* enjoys lessons that utilize diagrams, visuals, and videos to understand objects.

(4) *The verbal/survivor* likes explanations, requiring plenty of learning segments, narrations, and examples.

(5) *The active/socializer* prefers learning by doing, actively engaging in hands-on experiences to acquire knowledge.

(6) *The reflective/conqueror* enjoys reflecting upon learning materials and concepts learned at the end of a lesson.

(7) *The sequential/achiever* prefers spending time mastering materials and step-by-step practices of learned concepts.

(8) *The global/daredevil* prefers to advance through a lesson without necessarily completing every step, seeking challenges by skipping certain steps.

There are a few more studies to combine more than one feature to adapt gamified environments (Klock et al., 2020) such as behavior-performance (Utomo & Santoso, 2015), age-gender-player type-personality traits (Tondello et al., 2017).

Considering learners' performance and behaviors within a gamified environment, Utomo and Santoso (2015) personalized feedback for learners through four distinct pedagogical agents they designed. They concluded that the personalized experience had positive effects on learners' active learning behavior and motivation, and learners were satisfied with the recommendations tailored to themselves.

Tondello et al. (2017) categorized the most commonly used game elements into eight main categories considering user preferences: (1) Socialization, (2) Assistance, (3) Immersion, (4) Risk/Reward, (5) Customization, (6) Progression, (7) Altruism, and (8) Incentive. They investigated how user characteristics such as age, gender, player type, and personality traits influenced the scores within these categories, aiming to establish an adaptation framework that appeals to diverse user profiles. They used Hexad for determining player types and Five Factor Model for personality traits. The study has yielded following results:

- Socialization elements are favored by men, individuals with socializing tendencies, and extroverts.
- Assistance elements are preferred by women and extroverts.
- Immersion elements are favored by females, achievers, and free spirits.
- Younger achievers and players tend to favor Risk/Reward elements.
- Customization elements attract younger women who exhibit greater openness to new experiences.
- While the reasons behind progression preferences are not explicitly clarified by any studied variables, achievers and philanthropic individuals tend to like them more than others.
- Younger males, philanthropic individuals, socializers prefer altruism elements.
- Incentive elements are more appealing to younger players who have higher neuroticism scores on the scale.

Adaptation Process

In this section, we explain how adaptation occurs, involving both dynamic and static adaptation processes, as well as their combination, and how it is controlled, by

system or user. We address the adaptation process in two sections: user-controlled adaptation and system-controlled adaptation.

User-Controlled Adaptation

Adaptation process can be controlled by the user or by the system. If the personalization is user-initiated (Tondello & Nacke, 2020) or user-controlled, it is also called customization. In customized gamification learners have option or control to change the design. Lessel et al. (2016) offered users the freedom to choose what, when and how aspects will be gamified. Similarly, Tondello and Nacke (2020) compared a one-size-fit-all approach (control group) with a customized version (experimental group). Participants in the control group were all assigned the same game elements, while the participants in the control group were asked to choose from the eight game elements as many as they wanted to see in the design.

System-Controlled Adaptation

Personalization can also be controlled by the system. System-controlled personalization or system-initiated personalization is a process in which the system takes the initiative to select game design elements for users with or without using inputs from the users (Tondello & Nacke, 2020). This process is detailed as dynamic and static adaptation in the following section.

Dynamic and Static Adaptation. Current adaptation studies commonly use static adaptation which determines the user's state (player profile, game preferences, motivation, personality traits, etc.) only once and does not take into account changes that may occur in users during the use of the gamified platform (Hallifax et al., 2021). On the other hand, dynamic adaptation uses the information obtained from the user as a first step and then updates the user profile by following their interaction with the system and their behavior in the system (Hallifax et al., 2021; Rodrigues et al., 2022). Researchers aimed to automate the adaptation and address the challenges of achieving effective gamification design and adapting systems to each user by making use of machine learning and learning analytics in the dynamic adaptation process (Hallifax et al., 2021; Knutas et al., 2019).

Lavoue et al. (2019) presented a model that automates the adaptation of a learning environment used to teach French grammar and spelling based on player profiles. They adapted the learning environment in two ways: adapting the content and adapting the gamification. One of the game components included in the system is the stars that learners earn when they learn each grammar rule. Another component used is the leaderboard which is designed to show neighbors' performance rather than top performers. The effect of this 3-week implementation on learners' participation in the learning environment and motivation was investigated. Participants were divided into three groups; the first group received two adaptation elements most suitable for their BrainHex profiles, the second group received the least suitable two elements (counter-adaptation), and the third group did not receive any game elements. Analyzing the time learners spent in the system revealed that the use of adapted game elements increased engagement and led learners to spend more time in the system, while the group with counter-adaptation spent an average amount of time as the group without any game components. In terms of enjoyment, game components did not make a difference.

Dynamic adaptation does not necessarily mean full automation of adaptation. As in the study by Monterrat et al. (2015), it can also be applied by creating a profile at the beginning with the static adaptation approach and then changing the design according to the changes in the system movements. Halifax et al. (2021) proposed a model by using dynamic and static approaches together. In the static adaptation phase, learner profiles are created using certain tools before students start using the gamified system, and game components suitable for these profiles are integrated into the system. The next step involves tracking learners' behaviors in the system and recommending game elements to teachers to re-engage their students when their engagement drops.

Adaptation Data

In order to adapt gamification for different individuals, it is necessary to gather information about the learners, so this section focuses on how this information is collected.

There are several ways to gather information about learners for adaptation such as knowledge assessment, tests, questionnaires, user tracking and user model inference (Specht & Burgos, 2007). Jameson (2002) explores the collection of information about users, primarily emphasizing two categories: explicit and implicit methods. Explicit method includes the type of information that the learner provides explicitly for the system. On the other hand, the information obtained implicitly includes all user actions within the system that are not intended to reveal information about the user to the system (Jameson, 2002). In the following lines, we will also address information collection in two categories, explicit and implicit.

Explicit Information Collection

As Jameson (2002) mentioned self-reports, self-assessments, responses to test items, similarly Specht and Burgos (2007) mentioned that knowledge assessments, and questionnaires are categorized under explicit data collection. Examples include the scales employed to identify player types (Chtouka et al., 2019; Daghestani et al., 2020; Hallifax et al., 2019a; Lavoue et al., 2019; Oliveira et al., 2022; Tondello et al., 2016), learning styles (Altaie & Jawawi, 2021; Chtouka et al., 2019; Hassan et al., 2021), personality models (Codish & Ravid, 2014; Jia et al., 2016) or motivation profiles (Hallifax et al., 2020) in the studies.

Implicit Information Collection

Tracking the learners' actions that occur naturally within the gamified environment and sensor-based information (e.g. eye tracking) are kind of data obtained within the system implicitly (Jameson, 2002). This data may include their navigation paths, frequency of engagement, time spent on specific tasks, or the choices made within the system (Specht & Burgos, 2007). Hassan et al. (2021) used interactional data for adaptation. In their study, the system logs student interactions (type and duration) in the interaction log linked to their ID and stores information in the student model. Then, the system called "Learning Type Identifier" uses this data to create personalized profiles, and determine each student's learning dimension using these profiles (p. 550).

Bennani et al. (2022) employed machine learning algorithms to create learner profiles and adapt gamification dynamically based on the created profiles. Similarly,

Knutas et al. (2019) presented an algorithm-based personalized gamification system and showed how to use machine learning algorithms to adapt gamification dynamically according to learners' characteristics. Daghestani et al. (2020) created a system which combines educational data mining techniques, namely classification, gamification and adaptation. For the adaptation process, the system classified students using students' interaction data extracted from Moodle, and player types obtained by BrainHex questionnaire. López and Tucker (2018) introduced a machine learning method that predicts an individual's performance in a gamified task by using task-related information and facial expression data. Then the collected data was used for creating an "adaptive-individual-task" model and predicting individuals' performance in gamified tasks.

Adaptivity Intervention

Adaptive interventions involve gamification features that serve as interventions reflecting the outcomes of the adaptation process at the interface level (Böckle et al., 2018).

Common interventions include the delivery of suggestions and advice aimed at updating end users on their individual learning progress (e.g., notifications for deadlines, personalized feedback) and adaptation of game design elements and mechanics (Böckle et al., 2018). Providing personalized feedback or visualizing the feedback process, such as using dashboards that include the learner's current state and offering recommendations could be an example of adaptive intervention in gamified learning environments (Bayrak et al., 2021; Maher et al., 2020). Altaie and Jawawi (2021) implemented adaptive gamification on Moodle. They classified students based on the visual-verbal dimension of Felder-Silverman Learning Style. Both groups received the same learning materials; however, visual learners were presented with additional graphical materials, whereas verbal learners were given more textual materials. In addition, the game elements differed, with visual learners receiving progress bars, levels, badges, points, goals, teamwork, and feedback, while verbal learners were provided with points, challenges, teamwork, and feedback. Chtouka et al. (2019) aimed to adapt a gamified learning management system using a machine learning algorithm. The algorithm went through several iterations to find and suggest the optimal path that aligns with the learners' profile.

Conclusion and Suggestions

This study covers the fundamentals of gamification and sheds light on the current developments and potential direction of gamification studies. Our review shows how gamification is transitioning towards more adaptive forms to meet diverse learner needs and features. Studies have focused on the necessity of adaptive gamification in education to improve students' learning, achievements, and enthusiasm (Bennani et al., 2022). Specifically, research has demonstrated that adaptive gamification positively impacts various aspects of the educational experience. For instance, it has shown to enhance student engagement (Lavoue et al., 2019; Daghestani et al., 2020), participation (Kırmacı & Çakmak, 2024; Lavoue et al., 2019), and interaction (Kırmacı & Çakmak, 2024). Furthermore, adaptive gamification has been linked to increased motivation (Altaie & Jawawi, 2021; Hallifax et al., 2020; Utomo & Santoso, 2015) and higher

levels of satisfaction (Utomo & Santoso, 2015). These findings emphasize the potential of adaptive gamification to create more engaging and effective learning environments.

However, the terms used in the adaptive gamification context are used interchangeably and lack strict differentiation. In this regard, we examined literature and provided detailed definitions of the terms adaptive gamification, tailored gamification, personalized gamification, customized gamification, including adaptive and adaptable systems. To sum up, personalized gamification is a broad term covering any adjustments in the gamification design to address different learner needs and aspects. In customized gamification, the change(s) is made by the user/learner. While in tailored gamification the adjustments are made at the initial phase, in adaptive gamification the adjustments are dynamic and made by the system throughout the implementation process. So, it becomes evident that tailored gamification aligns with static adaptation, where adjustments are predetermined and implemented at the beginning. In contrast, adaptive gamification corresponds to dynamic adaptation, reflecting the system's ongoing adjustments throughout the implementation process.

In order to analyze how adaptive gamification studies are designed and what these designs are based on, we looked into studies through four main points: adaptation criteria, adaptation process, adaptation data and adaptation intervention. Adaptation criteria outline the basis on which the adaptation will be made. It includes player types, personality models, learning styles and hybrid profiles. In the examined studies, Bartle (Kırmacı & Çakmak, 2024; Kocadere & Çağlar, 2018; Marinho et al., 2019), Hexad (Hallifax et al., 2019a; Hallifax et al., 2019b; Tondello et al., 2017) and BrainHex (Chtouka et al., 2019; Daghestani et al., 2020; Lavoue et al., 2019; Oliveira et al., 2022) player typologies were utilized for categorizing player types, the Big Five Model / Five Factor model (Codish & Ravid, 2014; Jia et al., 2016; Tondello et al., 2017) and Myers-Briggs Type Indicator (González et al., 2016) were employed as the basis for personality modeling, and the Felder-Silverman model (Altaie & Jawawi, 2021; Chtouka et al., 2019; Hassan et al., 2021) was used to define different learning styles. Moreover, in some studies (Chtouka et al., 2019; Hallifax et al., 2020; Klock et al., 2020; Tondello et al., 2017; Utomo & Santoso, 2015) hybrid profiles were utilized for adaptation and integrating multiple aspects. Regarding the adaptation process, it goes through user-controlled or system-controlled adaptation. User-controlled adaptation is giving users the opportunity to control the adaptation process, and it is called customization. On the other hand, system-controlled adaptation processes are discussed under dynamic, static, or sometimes a combination of these approaches. In order to collect data for adaptation, researchers utilized various resources including questionnaires, scales, system logs and machine learning algorithms. Lastly, most of the studies adjusted game design elements and mechanics aiming intervention.

Lastly, reviewing existing studies also underlined framework limitations, insufficient number of empirical research, concerns related to automation and different use of terminology. It is stated that adaptive gamification is gaining popularity, but existing frameworks offer initial insights, and there is a need for comprehensive and in-depth research and development of standardized frameworks and guidelines for the implementation of adaptive gamification (Bennani et al., 2022; Oliveira et al., 2023; Rozi et al., 2019;). Clear and universally accepted models can offer a structured approach, ensuring better design and application of adaptive gamification strategies in

different settings. For sustaining adaptation and automation of the adaptive process, gamification analytics should be employed. This review, by synthesizing existing knowledge and identifying research gaps, serves as a foundation for future investigations in this field.

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Statement of Responsibility

The manuscript is part of the first author's PhD thesis under the close supervision of the second author.

Conflicts of Interest

The authors report there are no competing interests to declare.

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The Impact of Blended Mobile Learning on EFL Students' Vocabulary Development*

Harmanlanmış Mobil Öğrenmenin EFL Öğrencilerinin Kelime Gelişimi Üzerindeki Etkisi

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ABSTRACT: The study's objective is to examine the effects of Blended Mobile Learning (BML) on the vocabulary development of EFL preparatory students and their views of BML. As a mixed method study, it was conducted with 40 preparatory students at a state university in Turkey. While the control group studied vocabulary by reading texts only in the classroom by adhering to the textbook, the experimental group, in addition to the same instruction, was taught vocabulary outside the classroom in a virtual classroom opened through the Google Classroom application. A pre-test and a post-test were administered to the students to determine the impact of BML on their vocabulary development. The results of the tests were analyzed with SPSS program and the vocabulary development of groups was compared via an independent T-test. Additionally, a structured interview was done with the students of the experimental group to determine their views of BML. Students' responses were analyzed using the MAXQDA 2020 program with the method of content analysis. This research has led to the conclusion that BML, as a teaching method, strengthens the vocabulary development of the preparatory students and motivates them to learn vocabulary.

Keywords: Blended learning, vocabulary, mobile devices, mobile learning, SAMR.

ÖZ: Çalışmanın amacı Harmanlanmış Mobil Öğrenmenin (BML) İngilizceyi yabancı dil olarak öğrenen hazırlık öğrencilerinin kelime gelişimi üzerindeki etkilerini ve BML'ye ilişkin görüşlerini incelemektir. Bir karma yöntem çalışması olarak, Türkiye'deki bir devlet üniversitesindeki 40 hazırlık öğrencisi ile gerçekleştirilmiştir. Kontrol grubuna kelimeler sadece sınıf içinde ders kitabına bağlı kalınarak okuma metinleri ile öğretilirken, deney grubuna aynı eğitime ek olarak sınıf dışında Google Classroom uygulamasında oluşturulan bir sanal sınıf üzerinden kelimeler öğretildi. BML'nin kelime dağarcığı gelişimine etkisini belirlemek için öğrencilere bir ön test ve bir son test uygulandı. Testlerin sonuçları SPSS programı ile analiz edildi ve grupların kelime gelişimi bağımsız bir T-testi ile karşılaştırıldı. Ayrıca deney grubu öğrencilerinin BML'ye ilişkin görüşlerini belirlemek amacıyla yapılandırılmış bir görüşme yapılmıştır. Öğrencilerin yanıtları MAXQDA 2020 programı kullanılarak içerik analizi yöntemiyle analiz edilmiştir. Bu araştırma ile bir öğretim yöntemi olarak BML'nin hazırlık öğrencilerinin kelime gelişimini güçlendirdiği ve kelime öğrenmek için onları motive ettiği sonucuna varılmıştır.

Anahtar kelimeler: Harmanlanmış öğrenme, kelime, mobil cihazlar, mobil öğrenme, SAMR.

* This study is part of a dissertation titled "The Impact of Blended Mobile Learning on EFL Students' Vocabulary Development" which was presented as a poster *in Isatt2023: Living and Leading in the Next Era: Connecting Teaching, Research, Citizenship and Equity in Italy* in July 2023 at a conference, and the abstract was published in the proceeding book.

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Vocabulary is the backbone of four major language skills: speaking, listening, reading, and writing (Gorjian et al., 2011), and without extensive vocabulary knowledge, it is not possible to talk about language acquisition (Cortazzi & Jin, 1996). Wilkin (1972) asserted that "without grammar, little can be conveyed; without vocabulary, nothing can be conveyed" (p. 111); therefore, to build a strong base for language skills, any language learner must invest time in building vocabulary. In the long process of vocabulary development, the learners generally apply a particular vocabulary-developing strategy that is appropriate to their learning style. Though traditional vocabulary learning strategies were previously applied more and some of these techniques are still actively applied by learners, technological developments have caused some amendments in learners' vocabulary learning methods (Pun, 2013; Hao et al., 2021). For instance, to expand their vocabulary knowledge many students currently access online dictionaries and vocabulary teaching websites or applications exploiting mobile devices like tablets and smartphones which allow students to access vocabulary-developing materials anytime, anywhere, as well as provide instant feedback on their progress (Abraham, 2008; Chen et al., 2018).

Technology advancements have made it possible to learn vocabulary through a variety of approaches, including blended learning. Blended learning, also called hybrid learning (Olapiriyakul & Scher, 2006), has become a buzzword in education with different definitions that have evolved over 20 years of use (Sharpe et al., 2006). Educators and trainers frequently use the term, but there is no standard definition for it, and its meaning frequently changes depending on the context. According to Garrison and Kanuka (2004), blended learning is "the thoughtful integration of classroom face-to-face learning experiences with online learning experiences" (p. 96), and Graham (2006) defines it as "systems that combine face-to-face instruction with computer-mediated instruction" (p. 5). Dziuban et al. (2004) describe blended learning as "a pedagogical approach that combines the effectiveness and socialization opportunities of the classroom with the technologically enhanced active learning possibilities of the online environment, rather than a ratio of delivery modalities" (p. 3). Although blended learning does not have a standard definition and its meaning changes according to the context, its definition as a blend of face-to-face education and online learning is the most common one (Watson, 2008).

Marsh (2012) noted that instructional and educational methods that are most successful have consistently employed a range of strategies and tactics to improve skill development. According to Palalas (2013), blending is one of the most widely used approaches to learner-centered education in the twenty-first century and blending became one of the most well-liked educational ideas in EFL contexts and higher education after the 2000s (Halverson et al., 2014). Additionally, Watson (2008) asserted that in the future, blending would predominate as a teaching strategy and Kang (2010) stated that in-person or online training is weaker compared to blended learning instruction.

Blending can be accomplished in a variety of ways and with a variety of tools. In the 1990s, blended learning was accomplished with computers and computer-mediated tools, but it may now be practiced with the help of mobile devices, which penetrate into the society. The use of mobile devices to support face-to-face instruction has prompted the rise of the theory of blended mobile learning (BML), which is defined by Wong and

Ng (2018) as the usage of mobile technology in conjunction with the traditional face-to-face classroom environment and other e-learning tools. Suartama (2019) describes BML as "a special form of blended learning and a term used to describe learning opportunities where mobile technology supports situational learning activities and combines students' mobility with the concept of learning opportunities" (p. 6). Being a new term in the literature, the blended mobile learning method highlights that mobile devices can be used in formal education as supportive tools of face-to-face education. Through the combination of mobile language learning devices and face-to-face instruction, students can benefit from the advantages of both traditional and digital language learning tools. With such a method, students can maximize their language learning opportunities with a blend of portable language learning tools and face-to-face instruction.

In the literature, the number of studies pointing to the benefits of mobile devices expanding the vocabulary knowledge of EFL students (Averianova, 2012; Godwin-Jones, 2011; Stockwell, 2013) is not few, but these studies are mostly related to the discrete vocabulary learning, not as a part of the educational curriculum. How vocabulary is learned in a blended mobile environment and how the students' opinions are about the use of BML for vocabulary development are still not clear and need to be investigated. In this study, the impacts of BML on preparatory students' foreign language vocabulary development were investigated, and students' views of merging face-to-face instruction and mobile devices to learn vocabulary were researched. The findings of this study will shed light on the current vocabulary learning strategies and provide insight into BML's potential in the future. This study delves into two questions:

1. What are the impacts of BML on the vocabulary development of EFL preparatory students?

2. What are EFL students' views about the advantages of BML on vocabulary development?

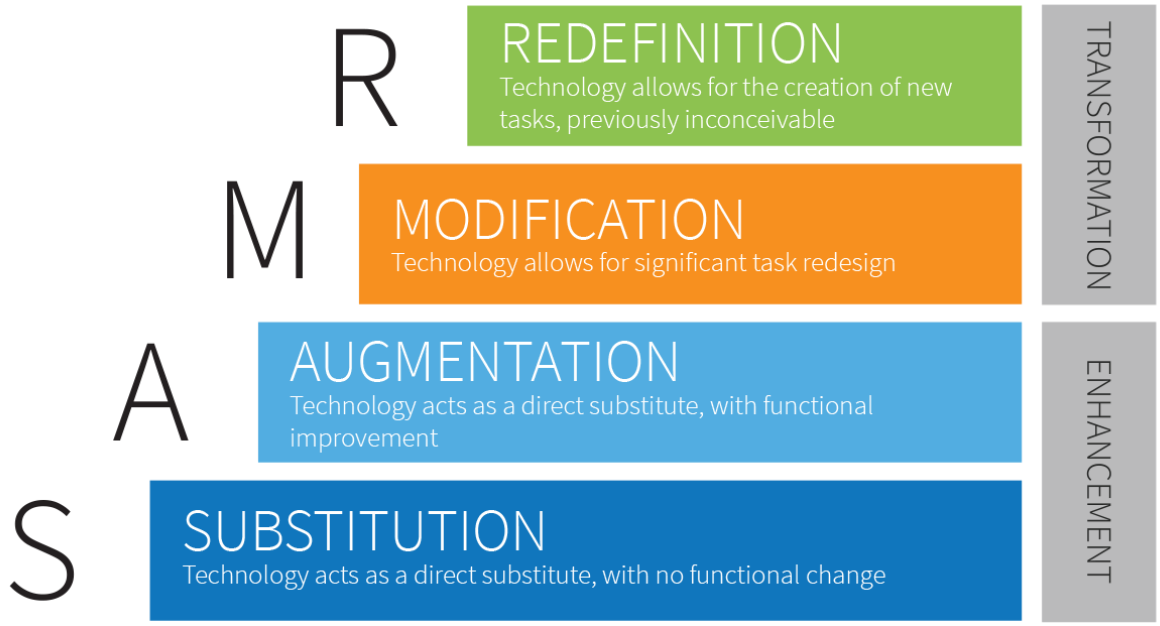
Conceptual Framework

The SAMR Model

In this study, as a technology integration framework, the SAMR Model was implemented. The SAMR, a four-stage model that describes how to use technology as an assisting instrument of face-to-face instruction, was created as a framework by Ruben R. Puentedura (2013) to classify and evaluate activities done via technological devices instead of traditional methods. To promote 21st-century skills for both educators and learners, SAMR facilitates the acquisition of proficiency in modern technologies and software in formal education. (Cummings, 2014). The four distinct processes that comprise the SAMR model are substitution, augmentation, modification, and redefinition. These stages represented visually in a hierarchical manner, are categorized under two separate headings as transformation and enhancement. Substitution and augmentation are designated as enhancement implying that instructors can use technology to enhance or replace current tools in the learning task, whereas modification and redefinition are classified as transformation indicating offering new learning opportunities that would not be easily achievable without technology. The SAMR model is shown with the details of each process in Figure 1.

Figure 1

The SAMR Model



Note. (Puendetura, 2013).

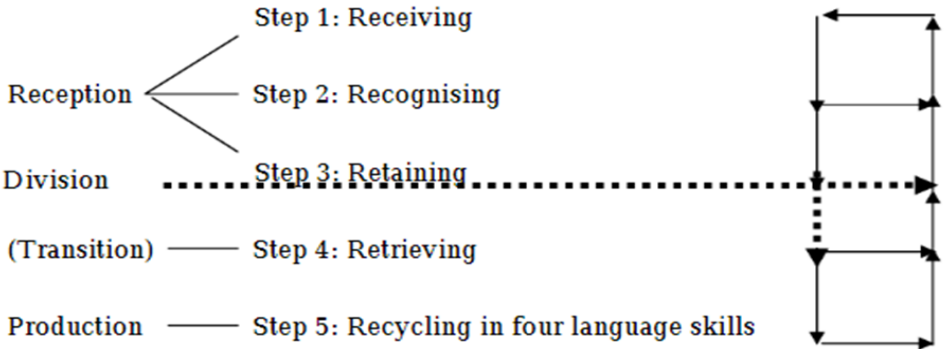
The SAMR model is a method for assessing every learning activity to ascertain the extent and complexity of technology integration (Kirkland, 2014). The model's objective is to motivate teachers to use technological tools or software both within and outside of the classroom to deliver valuable instruction, reduce resources, and save time. For example, it proposes to use an online exam as a substitute for a paper-based exam because it is easier, faster, and more environmentally friendly.

5R Vocabulary Learning Strategy

Another instructional method used in this research is the 5R vocabulary learning model. A study by Brown and Payne (1994) led to the emergence of a model that divided vocabulary learning strategies into five main groups. The first phase is having sources for learning new words, and the second is acquiring a distinct mental image of the new words' shape, whether it is aural, visual, or both. The next steps include understanding what the words mean creating a strong link between the word's form and meaning, remembering the word when needed, and finally employing the words (Hatch & Brown, 1995). These phases outline the actions that students have to take to understand a new lexical item correctly. Subsequently, as Figure 2 illustrates, Shen (2003) named these steps as receiving, recognizing, retaining, retrieving, and recycling (5R).

Figure 2

Steps of Vocabulary Learning



Step 1. Receiving: The learners can consciously or unconsciously be exposed to new terminology through reading, listening, and watching.

Step 2. Recognizing: Following the identification of new words, students consciously or subconsciously acquire the terms' definitions and forms.

Step 3. Retaining: For this level, inferring the meaning and form of the words from context might not be sufficient; thus, the learners may need some assistance from their peers, teachers, or a dictionary.

Step 4. Retrieving: The students can reach the word whenever they need it since the word is already stored in the memory. The learners can use the word but are still unable to spontaneously create sentences.

Step 5: Recycling: At this level, the learners are proficient in using words in all four skill areas.

Theoretical Framework

This study is based on two basic theories: ubiquitous learning and project-based learning. Ubiquitous learning means that learners access the resources and information they need from anywhere at any time (Hwang et al., 2008; Ogata et al., 2009). The penetration of mobile devices into every segment of society allows education to become ubiquitous. Thanks to mobile technology, students may access information and freely enhance their vocabulary knowledge, no matter where they are or what the time is. They can expand their vocabulary at midnight or very early in the morning, whether they are at a restaurant, in a dorm, in their bed at home, or somewhere else. In the application process of this study, students could ubiquitously reach and revise the reading passages and activities shared with them through a Google Classroom and improve their vocabulary knowledge.

Another theory that forms the base of this study is project-based learning, which has its origins more than a century ago in the work of philosopher and educator John Dewey, who founded the Laboratory School at the University of Chicago to study on the inquiry method. Students who take part in a project work on authentic and meaningful challenges related to their lives. By collaborating, students can explore topics, put forth explanations and hypotheses, debate their views, refute the ideas of others, and try out novel concepts in a project-based learning environment (Joseph et al., 2006). In light of technological advancements, problem-solving has become less

complex and can now be approached globally, facilitating the global sharing of solutions for social and environmental issues via social media platforms. In a project about a global issue, the solution or recommendation is commonly provided in English as a lingua franca language; therefore, students are inevitably exposed to words while reading for solutions and producing language while writing or communicating the solution. By facilitating global interaction, mobile devices help students enhance their vocabulary knowledge and allow them to use the words they have instructed.

Literature Review

Within the scope of the first research question of this study, many studies investigated the effect of blended education on EFL vocabulary development, and the majority of these studies showed that blended learning is more effective than face-to-face or online education. To study the effects of various delivery methods on enhancing language abilities, Kurucova et al. (2018) created three groups: the first group received instruction only online, the second group was instructed exclusively in person, and the third group was taught using a blended learning strategy. The researchers identified the linguistic abilities that had improved in each of the three groups by comparing the results of the pre-and post-tests. The reading, speaking, listening, and vocabulary scores of the blended-learning group improved dramatically compared to the others. Conducting a similar study to assess the impact of blended learning on vocabulary development, Sarajari and Gilakjani (2024) implemented a 10-week research involving 120 Iranian intermediate-level students. The findings revealed that compared to face-to-face education, blended learning instruction had a statistically significant positive effect on the vocabulary acquisition of Iranian intermediate EFL learners. Also, Alipour (2020) divided 90 EFL intermediate students into three groups to compare their vocabulary learning with face-to-face, online, and blended education. While giving face-to-face vocabulary training to the first group, she provided vocabulary to the online group with an LMS and to the blended group in a blended learning environment. At the end of a study of eight weeks, after the analysis of pre-and post-test results, she discovered that the blended learning group performed better than the online and in-person groups. Analyzing the results, she asserted that the reason why blended learning group performed better is because students value and need to incorporate technology into their education to make learning more enjoyable and engaging. A comparison study on the effects of traditional and blended teaching on the vocabulary acquisition of EFL learners was conducted by Khazaei and Dastjerdi in 2011. The goal of the study was to determine whether SMS could be effectively used alongside the blended learning strategy to instruct L2 vocabulary. This was assessed based on how well learners could detect and retain vocabulary terms. The findings showed that the group of students who received the learning material through traditional methods performed worse on tests compared to the students who received it through a blended teaching strategy.

Zumor et al. (2013) investigated the language development of EFL students at King Khalid University regarding the benefits and drawbacks of in-person language instruction and blended language learning via the Blackboard learning management system. A 33-item survey was completed by the 160 participants, and the results demonstrated that blended learning may greatly help students to increase their vocabulary in English. Ebadi and Ghuchi (2018) conducted a study on 40 EFL learners

to examine how the blended learning strategy affected Iranian students' vocabulary development in a blended mobile learning context. According to research outcomes, students who employed a blended learning approach demonstrated a statistically significant advantage in their academic performance when compared to those who solely utilized the face-to-face approach. Jia et al. (2012) found that students who took an English blended learning course with individualized vocabulary acquisition performed better in vocabulary acquisition.

There are not many empirical studies in the literature showing that blended learning instruction has a detrimental influence on learners' academic achievement. At Arabian Gulf University, Alshwiah (2009) examined the learning process of 50 students comparing the outcomes of a suggested blended learning method and face-to-face instruction. The results showed no statistically significant difference between the two groups in terms of proficiency. Tosun (2015) carried out a six-week study to examine the efficacy of the blended learning method for vocabulary development among 40 undergraduate students who attended rigorous English lessons at a prep class at the Middle East Technical University in Turkey. The experimental group studied the target vocabulary items using blended learning approaches, whereas the control group learned the same vocabulary using traditional education methods. Following the teaching period, both groups completed a written vocabulary exam. Additionally, semi-structured interviews were conducted with the students to explore their perspectives on blended learning. The study's findings showed that although students were satisfied with and preferred blended learning over conventional classroom instruction for vocabulary instruction, face-to-face instruction improved students' vocabulary proficiency more than the suggested blended learning technique.

The second research question of this study examines EFL students' perspectives on the advantages of BML on the vocabulary development of preparatory students. According to the outcomes of a study conducted by Ebadi and Ghuchi (2018) to explore students' perspectives towards blended learning regarding vocabulary development, blended learning offers benefits such as time flexibility, personalized learning, and organized design. The most significant benefit of blended learning, as indicated by a study conducted at a state university in Turkey by Saltan (2016), is accessibility, which enables students to attend classes whenever and wherever they choose. Following this are the abilities to create a private study area and to be time-efficient, thereby saving students from wasting time commuting to school. According to Delialioglu and Yildirim (2008), the blended approach is effective because it reduces the time students spend in class by about 66% and indirectly impacts teaching expenses. Ono and Ishihara (2012) investigated a new instructional model of blended learning by integrating the traditional Japanese classroom with Wi-Fi-connected mobile tools (iPod Touch, 2nd generation) and learning management systems (LMS). The study's findings demonstrated the positive impact of blended learning on students' vocabulary acquisition revealing that using mobile devices in the classroom increased students' enthusiasm to learn and heightened their awareness of language acquisition techniques. In summary, when considering the advantages of blended learning for vocabulary acquisition, the most prominent positive results include providing a conducive learning environment, saving time, and motivating students.

Methodology

Research Design

The explanatory sequential mixed method was applied for this study. This method involves gathering quantitative data before collecting qualitative data to address the research problem (Cresswell, 2012). By first analyzing quantitative data to measure students' vocabulary development and then gathering qualitative data to assess their opinions on blended mobile learning in vocabulary teaching, the study was able to provide a detailed understanding of the phenomenon under investigation. Employing this method allowed for a comprehensive analysis of the research problem, crucial for obtaining accurate results.

Overview of the Study

In the current study, the blending method consists of combining in-person instruction with online mobile learning. Specifically, face-to-face instruction was integrated with Google tools, such as Google Classroom, Google Docs, Google Slides, and Google Forms. These tools, which are available for free download on any platform, were utilized in the study. Throughout a 14-week study with preparatory students from the School of Foreign Languages of a state university in Turkey, the effects of blended mobile learning on the vocabulary development of B2 level EFL preparatory students were examined, as well as the learners' perceptions of that approach. Both the experimental group and the control group were taught vocabulary by the same instructor who is also the conductor of this study. In addition to the face-to-face instruction, members of the experimental group participated in additional vocabulary-building exercises via a virtual class the teacher had previously set up using the Google Classroom application. The detailed relationship between the application stages of the study and the methods applied in the study is charted and given in the appendix section.

Subjects of the Study

This study was conducted with 40 English preparatory students (33 female and 7 male), aged between 17 and 22, enrolled in the Department of the School of Foreign Languages at a state university in Turkey. These students have successfully passed the Foreign Language Examination conducted by ÖSYM, the official examination center of Turkey, and have been admitted to the departments of English Language Teaching or English Language and Literature. Before progressing to their respective departments, these students undergo a one-year preparatory training program within the framework of the School of Foreign Languages. The administration of the School of Foreign Languages had previously divided the students into two classes at random; therefore, there was no significant difference in proficiency levels between the students. Applying a simple random sampling method, the researcher assigned one class as the control group and the other as the experimental group at the beginning of the semester, before any information regarding the students' proficiency levels was available. Additionally, the fact that the control group performed better on the pre-test suggests that any potential bias in the group selection process was mitigated, as both groups started with similar proficiency levels.

Data Collection Tools and Data Analysis

Since it is a mixed methods study, this research incorporates both quantitative and qualitative data collection tools and analysis methods. In the initial phase of the study, which focuses on investigating the effects of BML on students' vocabulary development, a pre-and post-test, a quantitative data collection method, was utilized, and the gathered data were analyzed using the SPSS program. The subsequent phase of the study involves a qualitative inquiry into students' perspectives on vocabulary development through the BML method. In this part, structured interviews lasting 30 minutes were conducted with the students, and the acquired data were subjected to content analysis using the MAXQDA program. The collected data were transcribed, reviewed, thematically organized, and coded.

Pre-test and post-test: The pre-test included two sections with two parts each, and the questions were taken from the *Use of English* parts of the sample papers of the B2 First Certification Exam applied in 2015 by Cambridge Assessment, ensuring their reliability. After the test was created, it underwent a review of language and content by an expert instructor in the field. Necessary revisions were then made based on the feedback, and the test was piloted with a group of 30 students at the same proficiency level. The test was subsequently edited according to the students' feedback, ensuring its readiness for implementation. As the final version: each section of the test comprises two reading passages that resemble cloze tests. The first section assesses participants' vocabulary knowledge, featuring two reading passages with a total of 16 blanks for lexical items. In contrast, the second section evaluates participants' understanding of lexical item forms, consisting of two reading passages containing 18 blanks that require the correct word forms to be filled in. Then, the pre-test was administered to all participants in both groups to assess their initial vocabulary levels. Following the study period, the same set of questions from the pre-test was used for the post-test, which was conducted for both the experimental and control groups. To determine the difference in vocabulary levels between the two groups, an independent t-test (conducted using SPSS 26) was performed on their pre-test and post-test results.

A structured Interview: In this study, utmost care was taken to ensure that the interview form with five open-ended questions was valid and reliable. Three expert educators were consulted to assess the questions' validity, and their recommendations were taken into account to revise and recreate the questions. After a successful pilot period, the interviews were applied to the experimental group, and 16 out of 20 subjects showed up for the scheduled 30-minute interviews. This not only confirms the credibility of the study but also highlights the participants' willingness to contribute to the research. The researchers employed MAXQDA (2020) to examine the responses of the participants, utilizing content analysis to assess the qualitative data. The process encompassed transcription, rereading, and the creation and classification of codes, following a comprehensive and iterative analysis of the responses, following the approach prescribed by Strauss and Corbin (1990).

The process of qualitative data analysis:

Transcribing: The collected data were transcribed and the participants were randomly numbered from S1 to S16.

Data familiarization: The researcher read and reread the participants' replies to familiarize himself with the information.

Making the first codes: The investigator assigned the initial codes to the data, identifying the important features and assigning them to categories.

Searching for themes: The researcher gathered the primary codes and analyzed their connections with one another to identify potential themes.

Examining and improving themes: Before finalization, the researcher reviewed themes to ensure they accurately reflected the data they wanted.

Identifying and defining themes: The researcher investigated the inner workings of the well-liked themes and assigned them suitable names.

Ethical Procedures

Prior to commencing the study, ethical permission numbered 51974, dated 31.05.2022, was obtained from Istanbul Aydın University. Additionally, students were informed at the outset of the interview that their answers would be used solely for the purposes of this study and would not be shared elsewhere. Only volunteers were invited to participate in the interview, ensuring compliance with ethical standards and avoiding any violations in the study.

Findings

As outlined in the methodology section, the first research question constitutes the quantitative part of the study, while the second research question encompasses the qualitative aspect. The research findings are presented in this section in alignment with each research question.

Impact of BML on the Vocabulary Development

To address this research question, all participants underwent a pre-and post-test. The initial step in analyzing the results involved assessing the normality of the data to establish sample homogeneity. To achieve this, a Shapiro-Wilk test was employed to evaluate the distribution's normality of pre-test results.

Table 1

Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pre-test	0.138	40	0.053	0.981	40	0.710

As depicted in Table 1, the distribution of pre-test results was determined to be normal, as the significance level (0.710) exceeds 0.05, thus permitting the utilization of an independent t-test to investigate the difference between pre-and post-test outcomes.

A t-test was applied to measure pre-test and post-test averages discretely and their t-test ratios, as well as standard deviations.

Table 2

T-test According to the Results of the Pre-test and Post-test

	Group	N	Mean	Std. Deviation	t	p
Pre-test	Experimental Group	20	43.65	11.97	-0.70	.484
	Control Group	20	46.10	9.83		
Post-test	Experimental Group	20	60.50	10.38	3.26	.002
	Control Group	20	49.20	11.48		

As Table 2 illustrates, the pre-test mean scores for the control and experimental groups were 46.10 and 43.65, respectively. Even though this pre-study situation slightly favored the control group, the results of the independent sample t-test support the notion that there is no statistically significant difference between the experimental and control groups' pre-test mean scores ($t = -0.707$, $p > 0.05$). On the other hand, the control and experimental groups' respective post-test means were 49.20 and 60.55 showing a significant difference between the two groups ($t = 3.264$, $p > 0.05$).

Upon analyzing the variance between pre-and post-test results of the two groups, Table 3 illustrates that following the intervention, the experimental group exhibited an average increase of 16.85 points, while the control group demonstrated a mere 3.10-point increase. Also, the independent t-test reveals a statistically significant difference between the outcomes of the two groups ($t = 3.749$, $p < 0.05$).

Table 3

T-test According to the Difference between Pre-test and Post-test Results

	Group	N	Mean	Std. Deviation	t	p
Difference	Experimental Group	20	16.85	-1.59	3.74	.001
	Control Group	20	3.10	+1.65		

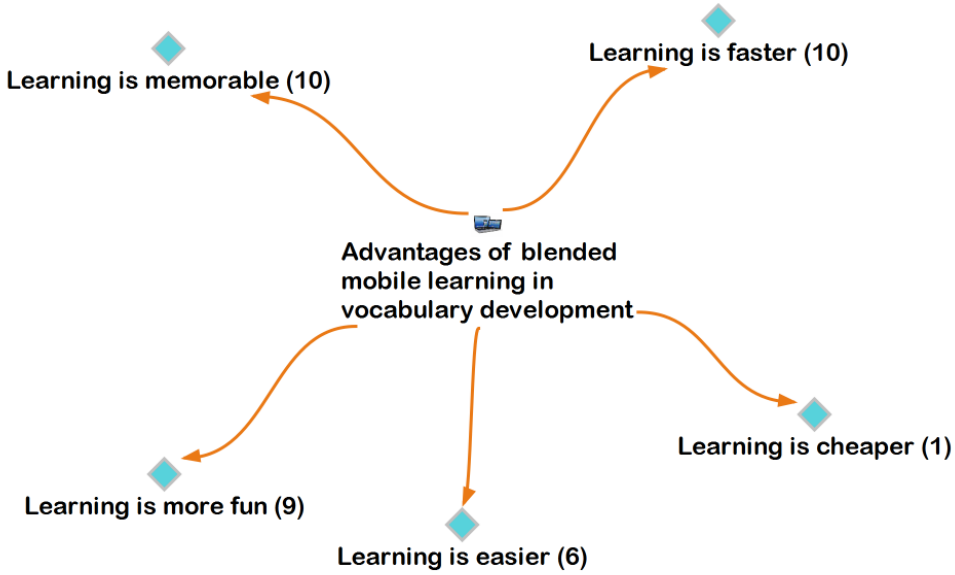
Furthermore, at the end of the study, it was observed that the standard deviation of the control group increased (+1.657), indicating a divergence in the vocabulary knowledge levels of the students in the control group. Conversely, the standard deviation of the experimental group decreased (-1.590), demonstrating a convergence in the vocabulary levels of the students, with their proficiency levels becoming more homogeneous.

EFL Students' Views About the Advantages of BML on Vocabulary Development

While the pre-and post-tests were applied to all participants (n=40), the structured interview was specifically conducted with 16 volunteers from the experimental group. To explore their views about the benefits of the BML in improving the vocabulary of EFL learners, the participants were asked about the advantages of BML. MAXQDA 2020 was used to analyze the data through content analysis. As Figure 3 depicts, EFL students consider that learning vocabulary with BML is more memorable, faster, more fun, easier, and cheaper.

Figure 3

Advantages of BML in Vocabulary Development



The advantages of using the BML method when learning vocabulary are listed below under distinct headings, backed up by the responses provided by the students.

Learning is More Memorable

There are different learning styles, such as visual, auditory, and tactile, and each student varies from the others on this point. According to Mayer (2002), materials containing both visual and auditory items at the same time are comprehended faster. As students expressed, mobile devices now have a wealth of educational applications and resources, and because these materials have many visual and aural components that cater to their learning preferences, learning supported by mobile devices is more memorable.

> My excellent visual memory made it possible for the word and its definition that I saw on the digital page to stick in my mind (S8).
>
> Because the visual effects in blended mobile learning are more captivating, learning is easier and can lead to greater retention of vocabulary in foreign languages (S14).

According to participants, another factor that makes vocabulary learning more memorable with BML was the fact that the apps were game- or puzzle-based, which was incredibly fascinating and captured students' attention more than teacher-led lectures.

> *When the words were in the form of a puzzle, it really helped me learn and retain the words that I was unable to memorize (S16).*

Learning is Faster

Mobile devices are ubiquitous in society, with nearly every adult owning at least one. Thanks to these devices, people can access information whenever they want without being constrained by time or location. Students expressed that in a blended mobile learning environment, they could swiftly and effortlessly acquire the necessary vocabulary without the need to wait for a tutor or attend a traditional course, all facilitated by the Internet.

When we encounter a word we are unfamiliar with, we can quickly learn it by looking up examples of its usage in sentences and solving puzzles involving it (S12).

We can quickly and efficiently find the words we are looking up thanks to mobile tools. It works well to quicken the process of learning vocabulary (S7).

Learning is More Fun

As a tech-savvy generation, many individuals expressed that supplementing traditional face-to-face lessons with technological devices such as smartphones or tablets could make the learning experience more enjoyable. Additionally, they noted that relying solely on in-person instruction to learn new vocabulary could be tedious, whereas utilizing mobile devices to learn on the go added an element of excitement and flexibility.

Being a technologically savvy generation, we find that learning vocabulary online is much more enjoyable. Furthermore, it becomes more enduring when we reinforce it through in-person instruction (S15).

Students have never been interested in learning vocabulary in a foreign language through traditional methods because they find it boring. Lying in bed after a long day and engaging in gamified vocabulary exercises on our smartphones is easier and more enjoyable (S5).

Learning is Easier

In the App Store and Google Play Store, numerous apps are concentrating on teaching language skills, particularly vocabulary skills, and students can reach them without time or place restrictions. Students stated that they could easily learn new words by using these apps or useful websites. That is, students now can access resources online that aid them in their extensive learning process, greatly simplifying what used to be a complex process.

I believe that mobile devices have a significant impact on education because I can memorize words from my phone at any time, which is very convenient (S10).

Nowadays, almost everyone owns a technological device, and accessing the internet is not a difficult task. No more attempting to learn words you do not know by using a pen and paper (S5).

Numerous apps support and ease language learning, thanks to technology (S11).

These days, technology permeates every part of our lives. Learning a language has been simpler as a result of mobile devices (S14).

Learning is Cheaper

Students revealed that they could access a greater variety of resources without having to pay any fees; therefore, they could ultimately save money. Since they previously often had difficulty getting printed resources due to high costs, students could now greatly benefit from this feature of technology. In contrast to the numerous expensive paper sources they previously had to use, they now have apps or PDFs, making learning less expensive.

This is a great thing for us students because, in this day and age of expensive foreign language resources, we have a lot of options with online applications rather than having to buy multiple books (S2).

Discussion

Besides discussing the results of the study, this section presents a comparison of the results with previous research, highlighting both the similarities and differences. Analysis of the impact of BML on students' vocabulary development revealed that,

following the study, the vocabulary knowledge of the students in the experimental group increased noticeably in comparison to the control group. It was detected that after the study of 14 weeks, the mean score of the experimental group grew by 16.86 points in terms of the difference between the results of the pre-and post-test, but the average score for the control group only enhanced by 3.10 points. Since there was a significant distinction between the two groups in the independent t-test findings ($t = 3,749$, $p<0.05$), it can be observed that the experimental group greatly benefited from the study. Additionally, it is notable to go over and compare the pre-test and post-test score distributions of the students in the control and experimental groups to get a clear picture of the effect of BML. When the increase analysis of the minimum scores obtained from the pre-and post-tests was practiced, only a 6-point increase was observed in the control group, compared to a 25-point increase in the experimental group, depicting the efficacy of vocabulary learning with the BML method compared to face-to-face education. Furthermore, the standard deviations of the groups' pretest and post-test results must be examined to conduct a thorough analysis of the study's impact. The standard deviation value is the one that shows how much the results deviate from the mean. The pre-test results showed that the standard deviation of the experimental group was higher than that of the control group, which means that compared to the experimental group, the vocabulary levels of the students in the control group are closer. The post-test, however, does not reveal this similarity because the levels of the experimental group participants converged (+1.657) while the disparity between control group members widened (-1.590).

All in all, contrary to the results of the studies by Alshwiah (2009), who obtained a statistically significant difference between the two groups in terms of proficiency, and Tosun, (2015) who found that face-to-face instruction improved students' vocabulary proficiency more than the suggested blended learning technique, the present study discovered that vocabulary learning in an educational programme conducted with blended mobile learning is quite effective compared to only face-to-face education, which is also compatible with many other studies (Kurucova et al., 2018; Alipour, 2020; Khazaei and Dastjerdi, 2011; Zumor et al., 2013; Ebadi and Ghuchi, 2018; Ono and Ishihara, 2012). It is worth noting that the significant increase in the post-test scores of the experimental group can be attributed to various factors, including the influence of mobile devices on ubiquitous learning. The use of mobile devices as a learning tool can provide learners with unfettered access to educational resources and facilitate learning outside the traditional classroom environment. Furthermore, mobile devices can enhance project-based learning by providing learners with wider and more enjoyable collaborative study areas which may have contributed to the success of the experimental group in achieving higher post-test scores as well.

In the second research question, the students in the experimental group were asked about the advantages of learning vocabulary with blended mobile learning, and the thematic coding was done according to the students' responses. Based on the feedback obtained from EFL students, it can be inferred that blended mobile learning offers a significant advantage in terms of permanent learning. This finding is consistent with the assertion made by Wenyuan (2017) and Khazaei and Dastjerdi (2011) and is in contrast to the observation of Saltan (2016), who posited that blended learning is less effective in terms of vocabulary retention compared to traditional face-to-face

instruction. Faster vocabulary learning is another benefit of BML according to the study's results, which is consistent with findings from studies by Delialioglu and Yildirim (2008), Ebadi and Ghuchi (2018), and Saltan (2016). Students' comments that vocabulary learning in a blended environment is enjoyable also align with the findings of Alipour's (2020) study, which thoroughly analyzed the data and came to the conclusion that students value and need technology because it makes learning more enjoyable, proposing the reason why blended and online learning groups outperform in-person instruction. Based on the feedback provided by the students, it can be inferred that one of the key advantages of BML is its potential to facilitate vocabulary acquisition, as highlighted by Saltan's (2016) concept of accessibility in language learning. Similarly, Ebadi and Ghuchi's (2018) research indicates that blended learning offers advantages like individualized instruction, time flexibility, and a well-organized layout. Finally, a few participants of this study mentioned the money-saving aspects of vocabulary learning in BML. Delialioglu and Yildirim (2008) noted that although the mean scores for the blended and traditional courses did not differ significantly, the blended learning approach worked well because it reduced class time by approximately 66% and had an indirect impact on instructional costs, which is a close result with the current study. Briefly, the findings of the student feedback revealed that the integration of mobile devices with traditional face-to-face instruction has resulted in several noteworthy benefits concerning vocabulary acquisition. Specifically, in the point of vocabulary development, blended mobile learning has been noted to enhance memorability, speed up the learning process, increase enjoyment, improve accessibility, and reduce costs, which makes it a promising pedagogical strategy.

Conclusion

The present study aimed to investigate the effectiveness of blended mobile learning (BML) in enhancing the vocabulary knowledge of students in preparatory classes, as well as their perception of the benefits of learning vocabulary via BML. The study revealed two significant findings. Firstly, BML was found to be highly effective in assisting EFL learners in developing their vocabulary, when compared to face-to-face instruction alone. Secondly, EFL students exhibited a positive attitude towards BML, citing it as a more memorable, faster, enjoyable, and cost-effective method of learning vocabulary, compared to traditional methods. This study adds to the body of research showing that using mobile devices to supplement in-person instruction helps foreign language learners to have a substantial vocabulary boost and enables ubiquitous learning and project-based learning.

Given that the younger generation devotes a substantial amount of their leisure time to mobile devices, educators must consider incorporating mobile tools into the curriculum to maximize learning outcomes. By leveraging blended mobile learning, students can collaborate outside the classroom to improve their vocabulary, thereby promoting a student-centered learning environment. Furthermore, the benefits of mobile devices can potentially alleviate teachers' workload in the classroom. In light of these findings, curriculum organizers and instructors should be mindful of the potential benefits of blended mobile learning and integrate such tools into their lesson plans accordingly.

Including only the advantages of BML and not focusing on the negative side of BML is a limitation of this study. The reason for that is participants' not revealing enough data about the negative side of the BML. The reason for that may be its being a very new method that students could not fully be aware of any negativity, or they thought there were no disadvantages to it. As its application increases, some other studies can focus on the negative side of the BML as well, comparing it to face-to-face learning.

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Statement of Responsibility

The authors have the same responsibility in writing any part of the article.

Conflicts of Interest

The authors have no conflict of interest to disclose.

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Appendix

Overview of the Study

<table>
<tr><th colspan="4">OVERVIEW OF THE STUDY</th></tr>
<tr><th>Vocabulary Teaching Method (5R)</th><th>Background Theory</th><th>Schedule of The Study</th><th>Technology Integration Method (SAMR)</th></tr>
<tr><td>Receiving
Recognizing</td><td rowspan="3">Ubiquitous Learning

Students could study and answer the questions anywhere and anytime without time and place restrictions.</td><td>First Four Weeks
During the first four weeks, a reading passage for each week was shared with students. Those reading passages were including different activities like comprehension or fill-in-the-blank questions. Also, for each week, an activity prepared via Wordwall application was shared with students via Google Classroom. Students' answers were discussed in the class.</td><td>SUBSTITUTION

Technology acts as a substitute, with no functional change.

Instead of the paper worksheets that can be given in the lesson, the students worked on the reading texts shared in PDFs over Google Classroom.</td></tr>
<tr><td>Retaining</td><td>Second Four Weeks
For each week, a reading passage with blanks was shared with the students via Google Classroom. The students were asked to find different forms of the highlighted words from the dictionary and write them down. The answers of the students about the different forms of words (parts of speech) were discussed in class.</td><td rowspan="2">AUGMENTATION

Technology acts as a substitute, with small functional improvement

Students used an online dictionary to check the appropriate meaning of the word according to context. They checked and learned the type of words.</td></tr>
<tr><td>Retrieving</td><td>Week 9
The students read the passage shared on Google Classroom in detail because there were questions about the passage. They also found the meanings of the highlighted words from the Oxford Learners dictionary and shared them on the virtual class on Google Classroom.</td></tr>
<tr><td rowspan="4">Recycling</td><td rowspan="4">Project-based Learning
Students discovered social or environmental problems and wrote a paragraph with solutions to these problems. Students collaborated with each other and corrected their paragraphs. Then they decorated this paragraph with pictures, made a slideshow, and saved this slide in mp4 format. They shared the video with the world and official authorities on their own YouTube channels.</td><td>Week 10
Students used the highlighted words in the passage in an sample sentence and shared their sentences on the virtual class. The classmates discussed these sentences by correcting or commenting.</td><td rowspan="2">MODIFICATION

Technology allows a significant task design.

Using the Google Classroom application provided an environment to the students for discussion and collaboration. With the help of their classmates, they could see their mistakes and corrected them.</td></tr>
<tr><td>Weeks 11 and 12
Students wrote a paragraph about an environmental or social problem and shared it with their friends on Google Classroom. The students evaluated the written paragraphs and made comments.</td></tr>
<tr><td>Week 13
By decorating these paragraphs with pictures. Students turned them into slideshows via Google Slide application.</td><td rowspan="2">REDEFINITION

Technology allows an inconceivable task design that cannot be done with traditional learning.

Sharing the videos in which they found solutions to social problems on their YouTube channels and ensuring that these solutions reach the necessary authorities and the world is an impossible thing to be done with traditional methods.</td></tr>
<tr><td>The last week
Students recorded the slide they prepared as mp4 by adding a background music, and posted it on their YouTube channels.</td></tr>
</table>

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Investigation of the Concept Images of Mathematics Educators and Preservice Mathematics Teachers Regarding Slope, Rate of Change, and Derivative*

Matematik Eğitimcileri ve Matematik Öğretmen Adaylarının Eğim, Değişim Oranı ve Türeve İlişkin Kavram İmajlarının İncelenmesi

Ramazan EROL** **Elif SAYGI*****

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ABSTRACT: The aim of this study is to examine the concept images of mathematics educators and pre-service elementary mathematics teachers regarding the relationships between the concepts of slope, rate of change and derivative. Four mathematics educators working in different state universities and responsible for Analysis courses, three pre-service elementary mathematics teachers who successfully completed the Calculus 1 course at a state university, and four pre-service elementary mathematics teachers who successfully completed the Calculus 1 and Calculus 2 courses participated in the study. In order to determine the concept images of the participants about the concepts of slope, rate of change and derivative, the participants were asked semi-structured interview questions prepared by the researcher and application questions including the second stage questions. The audio recordings obtained from the interviews were transcribed and then the second stage questions were applied to the participants. The second stage questions were received in writing from the participants and analysed by the researcher through descriptive content analysis. As a result of this study, mathematics educators were able to use the concept images they had in the first stage questions in the second stage questions. On the other hand, pre-service elementary mathematics teachers were able to use the concept images they had in the first stage questions in the second stage questions.

Keywords: Concept image, slope, rate of change, derivative, mathematics educator.

ÖZ: Bu araştırmanın amacı matematik eğitimcilerinin ve ilköğretim matematik öğretmen adaylarının eğim, değişim oranı ve türev kavramları arasındaki ilişkilerine yönelik kavram imajlarını incelemektir. Araştırmaya farklı devlet üniversitelerinde görev yapan ve Analiz derslerinden sorumlu dört matematik eğitimcisi ve bir devlet üniversitesinde Analiz 1 dersini başarıyla tamamlamış üç ilköğretim matematik öğretmen adayı, Analiz 1 ve Analiz 2 dersini başarıyla tamamlamış dört ilköğretim matematik öğretmen adayı katılmıştır. Eğim, değişim oranı ve türev kavramları hakkında katılımcıların kavram imajlarını belirlemek üzere, katılımcılara araştırmacı tarafından hazırlanan yarı yapılandırılmış görüşme soruları ve ikinci aşama sorularının yer aldığı uygulama soruları yöneltilmiştir. Görüşme sorularından elde edilen ses kayıtları transkript edilmiş ve daha sonra katılımcılara ikinci aşama sorular uygulanmıştır. İkinci aşama sorular katılımcılardan yazılı olarak teslim alınarak araştırmacı tarafından betimsel içerik analizi ile incelenmiştir. Bu araştırmanın sonucunda matematik eğitimcileri birinci aşama sorularda sahip oldukları kavram imajlarını ikinci aşama sorularda da kullanabilmişlerdir. Bununla beraber ilköğretim matematik öğretmen adayları ise birinci aşama sorularda sahip oldukları kavram imajlarını ikinci aşama sorularda da kullanabilmiştir.

Anahtar kelimeler: Kavram imajı, eğim, değişim oranı, türev, matematik eğitimcisi.

*This study is produced as Ph.D. dissertion of the first author under the supervision of the second author at Hacettepe University.

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The influential social scientist Kurt Lewin once stated, “There is nothing so practical as a good theory” (Lewin, 1951, p.169). According to Poincaré (1908), the practical value of a good theory stems from understanding mathematics learners. Therefore, studying learners through a solid theoretical framework can provide valuable insights into the research topic.

Despite its significant role, mathematics is widely acknowledged as a complex discipline to learn, often associated with fear and anxiety (Ashcraft & Ridley, 2005). According to the literature, educators and learners must have a clear and meaningful understanding of mathematical concepts (Bingölbali et al., 2016; Dreyfus & Eisenberg, 1982; Habre & Abboud, 2006; Heinze et al., 2009; Sfard, 2000, 2005). Vinner (1983) notes that incorrect examples during instruction can lead to misconceptions and incorrect learning, emphasizing the importance of accurate conceptual understanding.

Meaningful relationships among mathematical concepts are interconnected (Ministry of National Education [MoNE], 2018, 2024). Understanding these concepts’ accurate representation is crucial for meaningful learning outcomes in teaching (Bartell et al., 2013; Çakıcı et al., 2006; Goldsmith et al., 2014; Tzur & Simon, 2004). Given the spiral nature of mathematics, education progresses from patterns in preschool to advanced topics like functions, limits, and derivatives in high school, continuing into higher education.

Calculus is one of the most crucial subjects in higher education mathematics, focusing on understanding changes and predicting the future (Dreyfus, 2022; Turner & Álvarez, 2021; Vinner, 2002). The calculus course, essential from secondary school to postgraduate studies, requires high-level mathematical thinking and reasoning (Kuzu, 2021). It covers concepts such as limits, derivatives, and integrals, promoting inquiry, reasoning, and mathematical thinking (Artigue, 2002; Cohen, 2012; Ergene, 2019; Konyalıoğlu et al., 2011; Kuzu, 2021; Lithner, 2004; Mueller, 2004; Strasser, 2010; Thomas & Finney, 2001). Initially presented as groundbreaking work by Leibniz and Newton, calculus represents one of the most vital discoveries in mathematics (Bingölbali, 2010). But according to Tall (1993), the calculus course can have different meanings and interpretations, varying from country to country.

Advanced topics requiring high-level knowledge and skills are often challenging for learners to understand and internalize (Bukova, 2006; Cornu, 1981; Doruk et al., 2018; Dreyfus & Eisenberg, 1982; Grover, 2015; Tall, 1993; Tall & Vinner, 1981; Thomas & Finney, 2001; White & Mitchelmore, 1996). Studies abroad have shown that reports published by various mathematics groups in the United States during the 1980s reflect this challenge regarding the calculus course (National Council of Teachers of Mathematics [NCTM], 1987). MAA and NCTM concur that the teaching of calculus could have been more effective (Grant et al., 2016). To address these challenges, the Harvard Core Calculus Consortium Project emphasized teaching calculus concepts numerically, algebraically, and graphically (Moore & Smith, 1987). Gleason and Hallett (1992) highlighted the importance of teaching calculus through “The Rule of Three”, involving graphical, numerical, and algebraic instruction. Thus, calculus courses hold a significant place in mathematics. Understanding the foundational concepts of calculus requires a relationship with other mathematical concepts such as algebra, geometry, and trigonometry, making it the first step for subsequent mathematical topics (Sağlam,

2011). From this perspective, calculus is a fundamental course in mathematics education.

Changes in mathematics instruction have been acknowledged significantly, with many efforts to modify the curriculum and instruction. Notably, the main change in the calculus course is the increased focus on conceptualization and visualization (Habre & Abboud, 2006). Zimmermann (1991) considers visualization the core of the most substantial fundamental change in mathematics education: conceptual learning. He explains, "Conceptually, the role of visual thinking is so pivotal in understanding calculus that it would be challenging to conduct a successful calculus course without emphasising the visual aspects of any topic" (Zimmermann, 1991, p.136).

In mathematical activities, concepts are used not only in formal definitions but also in individual mental representations. These models, which exist before learning the mathematical concept, arise from experiences and are further reinforced by the learned concept (Cornu, 1981). However, even a correctly defined concept can sometimes lead to cognitive conflicts in students (Tall, 1988). Reported mental conflicts include difficulties with the representation and verbal expression of decimal numbers (Tall, 1977), the definition and expression of functions (Vinner, 1983), challenges with limits and continuity (Tall & Vinner, 1981), and the limit of functions (Ervynck, 1983).

In Turkey, middle school mathematics teacher candidates first encounter the concept of derivatives in Calculus 1 courses in the high school curriculum (MoNE, 2018, 2024). Considering the examination system, teacher candidates solve the fundamental concepts of limits, continuity, derivatives, derivative applications, and reading graphs at an operational level quickly and using test techniques (Dündar, 2015; Erdoğan, 2017).

Aim

The purpose of this study is to investigate the conceptual understanding of preservice elementary mathematics teachers and mathematics educators teaching calculus courses (Calculus 1, Calculus 2, and Calculus 3) about the concepts of slope, rate of change, and derivative, as well as the interconnections among these concepts. Students often rely on their mental images rather than formal definitions when learning mathematics. Therefore, research on concept images holds substantial significance in this context. The concept of derivative is one of the most important and fundamental concepts of calculus, both in terms of preparation for subsequent courses (e.g. differential equations) and in terms of its relationship with previous concepts (e.g. function, limit, continuity). Effective understanding of the concept of derivative requires knowledge of the slope, rate of change/instantaneous rate of change relationship. Therefore, it is important to examine the concept images of mathematics educators, who are one of the important factors in students' learning of these concepts. A qualified mathematics teacher is expected not to have false concept images that may cause mislearning and misconceptions. In mathematics educators, concept definition and concept images about the concept of slope, rate of change and derivative are expected to be a cognitive activity between the definition cell and the image cell as in Tall and Vinner's (1981) conceptual framework. According to some mathematics educators, regardless of the context in which the concepts of slope, rate of change and derivative are presented, it may be possible to present a coherent, meaningful interpretation of

these concepts. In line with these aims, the research pursued answers to the following questions:

1. What are the concept images of pre-service elementary mathematics teachers about the relations of slope and instantaneous rate of change with derivative?
2. What are the concept images of the Mathematics Educators about the relations of slope and instantaneous rate of change with derivative?

Method

The study was based on a qualitative research approach. In the qualitative research, human behaviour is more meaningful if it is handled flexibly and holistically in research. In this context, the opinions of individuals, their behaviours, and their experiences in the natural environment have an important place in the research. In this context, a case study, one of the qualitative research designs, was used. In the case study, the boundaries of the situation are clear. It is a design that allows in-depth examination and investigation of a phenomenon, individual, group, or system (Bassey, 1999; Punch, 2005). For this reason, holistic multiple case design, one of the case study designs, would be used in the planned study. In the holistic multiple-case design, more than one situation can be perceived as holistic. Therefore, each situation is considered holistically in itself and compared with each other (Yıldırım & Şimşek, 2016). The situations in the study are analysed separately and then compared. The cases examined in this study are the concept images of each pre-service elementary mathematics teacher and mathematics educator and the concepts of slope, rate of change/instantaneous rate of change, and derivative. Concept images about each concept and concept images about the relationship of these concepts with other concepts constitute the cases of this study. Although concept images about these concepts are discussed separately, their relations with each other constitute a unity. To make sense of the study in all aspects, as Creswell et al. (2007) mentioned, many data were utilised during the study. In addition to the audio recordings of semi-structured interviews, the participants' written records were also used as data collection sources. The present study was conducted with mathematics educators working at different state universities who taught derivatives in their calculus courses (Calculus 1, Calculus 2, and Calculus 3) and prospective elementary mathematics teachers studying at a state university.

Due to the pandemic period, the study group research consisted of 7 pre-service teachers and four mathematics educators who were studying in a state university's elementary mathematics teaching programme and received a grade of BB or above in the Calculus 1 course. According to the relevant state university's undergraduate education and training examination regulations, the BB success grade, the success coefficient is 3.0, and the percentage equivalent is determined as 75-84. Because of students with a BB grade or higher have a certain level of academic success, making them suitable for analysing their concept images. In this respect, pre-service teacher participants were selected by purposive sampling. The sample consisted of n=3 pre-service teachers in the first year and n=4 in the second year. In addition, four mathematics educators working in different universities and responsible for the Calculus 1 course took part in the study.

Table 1

Demographic Information of the Pre-Service Elementary Mathematics Teachers Who Participated in the Study

Prospective Teacher	The Type of High School That Pre-Service Teachers Graduated From	Grade Level	Calculus1 Grade
Ö1	Science High School	2	BB
Ö2	Anatolian High School	2	BA
Ö3	Science High School	2	BB
Ö4	Science High School	1	AA
Ö5	Science High School	1	BA
Ö6	Anatolian High School	1	AA
Ö7	Anatolian High School	2	BB

When Table 1 is analysed, it is seen that the high schools the participants graduated from are predominantly Science High School and Anatolian High School. Considering the knowledge of prospective elementary mathematics teachers, it was thought that their concept images about slope, rate of change and derivative could be determined. Prospective elementary mathematics teachers need to be successful in the Calculus 1 course to determine their concept images about the concepts of analysis course (slope, rate of change and derivative), which require high-level knowledge (Orton, 1983).

Table 2

Demographic Information of the Mathematics Educators Who Participated in the Study

Mathematics Educator	Undergraduate Graduation	Postgraduate Graduation	Academic Title	Seniority
ME1	Elementary Mathematics Teacher Education	Elementary Mathematics Education	Asst. Prof.	5
ME2	Elementary Mathematics Teacher Education	Mathematics	Asst. Prof.	7
ME3	Secondary Mathematics Teacher Education	Mathematics	Assoc. Prof.	6
ME4	Elementary Mathematics Teacher Education	Elementary Mathematics Education	Asst. Prof.	3

Mathematics educators are responsible for Calculus 1, Calculus 2 and Calculus 3 courses. In this context, the mathematics educators participating in the study were selected by criterion sampling.

The pre-service elementary mathematics teachers who participated in the study were coded as Ö1, Ö2, Ö3, Ö4, Ö5, Ö6, and Ö7. Data were collected from the participants in order to examine the concept images of pre-service elementary mathematics teachers about the concepts of slope, rate of change and derivative. Firstly, semi-structured interviews were conducted. Then, the first stage of the second stage

questions, including the application questions (questions 1, 2, and 3), were carried out. Finally, the answers of the prospective elementary mathematics teachers to the scenario questions in the second stage questions (Questions 4, 5, 6, and 7) were collected. Due to the pandemic, the data were collected face-to-face with the participants in the same settlement by taking necessary precautions. Unlike the pilot data, semi-structured interviews were conducted face-to-face with some pre-service elementary mathematics teachers (Ö6, Ö7, and Ö1). The interviews were video and audio recorded. The other participants (Ö2, Ö3, Ö4, Ö5) participated in semi-structured interviews online as in the pilot study. The data collection process started with semi-structured interview questions at the end of the autumn term 2020-2021. In the second stage (practice questions), answers were collected after the semi-structured interview questions were analysed.

The mathematics educators participating in the study were coded as ME1, ME2, ME3 and ME4. The data collection process with the mathematics educators was similar to that of the pre-service elementary mathematics teachers. The study's data were collected by determining the appropriate times for mathematics educators to participate. Semi-structured interviews were conducted face-to-face with ME1 and ME4. The second stage questions were received in written form. Semi-structured interviews with ME2 and ME3 were conducted online. The questions of the second stage were obtained from ME2 and ME3 in the digital environment.

The Data Collection Tools

The data collection tools of the study consisted of questions prepared by making use of the related literature and composed of two stages examining the relationship between slope, rate of change and derivative. The first stage questions consisted of seven semi-structured interview questions, and the second stage questions (application questions) consisted of seven open-ended questions, including one scenario about the relationship between derivative, slope and rate of change/instantaneous rate of change. Sub-dimensional questions in the second stage belong to the 1st, 2nd, and 3rd questions. Together with these sub-dimensional questions, the second stage consists of 12 questions in total. Three mathematics educators who are experts in the field examined the prepared data collection tools. In line with the expert opinions, the final version of the data collection tools was created, and the study was started.

Data Analysis

In the application dimension of the study, semi-structured interviews consisting of first-stage questions were conducted with each pre-service teacher for an average of 55 minutes. Considering the pandemic conditions, similar to the pilot application, the interviews were recorded online with video and audio recordings. In addition, semi-structured interviews with three pre-service teachers were conducted face-to-face. Face-to-face interviews were audio and video recorded in the same way. Two stages of the second stage questions were collected from pre-service elementary mathematics teachers. The answers to the first three questions were asked in the first stage. After a brief break, the answers to the last four questions containing scenarios were asked. The researcher stayed in the same environment as the participants while answering the questions. Audio and video recordings were made online with the other four pre-service teachers. The answers to the second stage questions were similarly asked online from 4 pre-service elementary mathematics teachers by taking video and audio recordings. For

the second stage questions given online, pre-service teachers were asked to have their cameras turned on and to give their answers in front of the camera. The answers to the second stage questions were received digitally from the elementary mathematics teachers for the online interviews. For the second stage questions, the pre-service elementary mathematics teachers were asked to answer the first three questions at the first stage, and then a break was given. Care was taken to keep the camera on even during the break. Then, they were asked to answer the last four questions containing scenarios. Semi-structured interviews were conducted face-to-face with two mathematics educators by audio and video recording. Interviews with the other two mathematics educators were audio and video recorded online, considering the pandemic conditions. The second stage questions were received digitally from all math educators.

The researcher transcribed and analysed the first stage questions after the semi-structured interviews with pre-service elementary mathematics teachers were audio and video recorded. In the analyses, an analysis framework was used for each concept to determine the concept images about the ideas of slope, rate of change/instantaneous rate of change and derivative. Similarly, semi-structured interviews with mathematics educators, which were audio and video recorded, were transcribed and analysed. Similarly, the data of mathematics educators were analysed by using the analysis framework determined for each concept to reveal their concept images.

The second stage questions were analysed by examining the written answers given by primary school mathematics teachers. The answers given to the second stage questions were carried out online. Concept images about the concepts of slope, rate of change and derivative were revealed using the analysis frameworks by examining the semi-structured interview questions including the first stage questions and the answers given in the second stage questions. Similarly, the answers of mathematics educators to the first and second stage questions were determined by using analysis frameworks and their concept images were tried to be determined according to Tall and Vinner (1981).

The concept images of the concepts of slope, rate of change/instantaneous rate of change and derivative in the data obtained from semi-structured interview questions and open-ended questions were analysed in the context of different analysis frameworks and the concept images of mathematics educators and prospective elementary mathematics teachers were determined. As the theoretical framework, conceptual frameworks of the concepts in the study were used in the light of Tall and Vinner (1981) concept image and concept definition theoretical framework. The conceptual frameworks in the theoretical framework dimension of the study are explained as analysis frameworks in the method section.

Validity and Reliability

One of the ways to increase credibility in qualitative research is that it is carried out under expert control (Merriam & Tisdell, 2015; Yıldırım & Şimşek, 2016). In this context, all stages of the study were checked and evaluated by more than one expert. Within the scope of the research, the concept image codes determined within the scope of the data collection tool for the concepts of slope, rate of change/instantaneous rate of change and derivative were coded independently by different experts and the inter-coder consensus coefficient was calculated to determine whether there were differences between the coders. The consensus coefficient was obtained by considering the whole

codes in the analysis frameworks used in the research. Reliability=Number of agreements/(Number of agreements+Number of disagreements), Reliability=19/(19+4), Reliability=.82. Inter-coder agreement is .82 and according to Fahy (2001), values above .70 are acceptable.

Slope Concept Analysis Framework

The studies and analysis frameworks related to the concept of slope are mentioned in the conceptual framework and related research section of the study. The concept images of mathematics educators and elementary mathematics teachers for the concept of slope were analysed using the analysis framework by Moore-Russo et al. (2011) in their study. Since the codes in Moore-Russo et al. (2011) analysis framework are more descriptive and detailed, this framework was used.

Table 3

Analysis Framework for the Slope Concept

Category	Slope	Code
Geometric Ratio (G)	"Rise over run" division of changes in y by changes in x	G1
	Vertical displacement (distance, change) over horizontal displacement (distance, change)	G2
Algebraic Ratio (C)	y divided by x change	C1
	Representation of the ratio with algebraic expressions, (y2-y1)/(x2-x1)	C2
Physical Property (F)	The property of the line often described using terms like "steepness" ("slope", "step", etc.); "How high it goes" or "goes up"	F
Functional Property (f)	Constant rate of change between variables	f
Parametric Coefficient (PK)	The coefficient m in the equation y = mx + b	PK
Trigonometric Understanding (T)	Tangent of the slope angle of a line	T1
	Direction component of a vector	T2
Calculus Understanding (K)	Limit	K1
	Derivative	K2
	Tangent line to a curve at a point	K3
Real World Situation (GD)	Static, physical situation (e.g., wheelchair ramp)	GD1
	Dynamic, functional situation (e.g., distance vs. time)	GD2
Determining Feature (B)	Feature determining parallel, perpendicular lines	B1
	Feature that can determine a line given a point	B2
Behavior Indicator (D)	Real number indicating the increasing, decreasing, horizontal tendencies of the line	D1
	Real number indicating the magnitude of the increase/decrease of the line	D2
	Real number indicating if the line is positive or negative, must intersect the x-axis	D3
Linear Constant (S)	Feature unaffected by translation	S1
	Constant feature unique to "straight" numbers	S2
	Constant feature independent of representation	S3

Note (Moore-Russo et al., 2011).

Rate of Change/Instantaneous Rate of Change Concept Analysis Framework

The studies and analysis frameworks related to the concept of rate of change/instantaneous rate of change are mentioned in the study's conceptual framework and related research section. The concept images of mathematics educators and elementary mathematics teachers for the rate of change/instantaneous rate of change concept were analysed using the analysis framework put forward by Hauger (1995).

Table 4

Rate of Change / Instantaneous Rate of Change Concept Analysis Framework

Category	Rate of Change	Code
Universal (Global)	Evaluates the general characteristics of the graph: increasing, decreasing, and changing rates.	D1
Interval	Addresses the directions of the average rate of change.	D2
Point-wise	Involves participation in the instantaneous rate of change.	D3

Note (Hauger, 1995).

Analysis Framework for Derivative Concept

The studies and analysis frameworks related to the concept of derivative were also mentioned in the study's conceptual framework and related research section. The concept images of mathematics educators and pre-service elementary mathematics teachers for the derivative concept were determined using the analysis framework put forward by Zandieh (2000).

Table 5

Analysis Framework for Derivative Concept

	Contexts				
	Graphical	Verbal	Physical	Symbolic	Other
Process-object pairs	Slope	Ratio	Speed	Division of Differences	
Ratio					
Limit Function					

Note (Zandieh, 2000).

Zandieh (2000) stated that he developed his framework by examining how the concept of derivative is defined in textbooks and by observing mathematics educators, mathematicians, calculus students in the classroom and their understanding of the concept of derivative. Each cell in Table represents one aspect of the concept of derivative. In the conceptual framework created by Zandieh (2000), the concept of derivative can be understood in the following ways:

a- graphically, the slope of a line tangent to a curve at a point,

b-the instantaneous rate of change verbally,

c-physical speed or velocity,

d-can be symbolically presented as the limit of differences

Ethical Procedures

The ethics committee permission for the study, which was created from the relevant doctoral thesis, was obtained from Hacettepe University on 15. 03. 2021 with the number E-35853172-300-00001497785.

Results

Elementary Mathematics Teacher Candidates' Concept Image about the Relations of Slope and Instantaneous Rate of Change with Derivative

In the sub-problem of the research, the concept images of prospective elementary mathematics teachers about the relationship between the concepts of slope and instantaneous rate of change with the concept of derivative were analysed. The way followed here, the concept image of slope and the analysis framework of rate of change/instantaneous rate of change were analysed. In the first stage questions, "Is there a relationship between the concepts of derivative, instantaneous rate of change/rate of change and slope? If so, what kind of a relationship is there? Explain." This situation was analysed with the question in Table 6, which is one of the second stage questions.

Table 6

The Question About the Relationship Between Derivative, Slope and Instantaneous Rate of Change in the Second Stage Questions

Zeynep and Yeliz discuss the meaning of the derivative concept. Zeynep stated that the derivative at a point is equal to the rate of change at that point and the slope of the tangent drawn to the function at that point. Zeynep told Yeliz that $f(x) = x^2$ *the instantaneous rate of change, derivative and slope of the function at the point x=2 are equal to 4. Yeliz claimed that the slope at x=2 could be equal to the derivative. If you were Zeynep, how would you help Yeliz and how would you explain the relationship between these concepts?*

Table 7

Concept Images of Prospective Mathematics Teachers in the First Stage Questions

Participants		Ö1	Ö2	Ö3	Ö4	Ö5	Ö6	Ö7
		Images						
The relationship between derivative-instantaneous change and slope	Instantaneous change	Point	Point	Point	Point	X	X	X
	Slope	K2	T1	G1	K2	X	X	X
	Derivative	V-R-R/L/F	G-S/R	P-S-R	G-V-F	X	X	X

V: Verbal, R: Ratio, G: Graphical, S: Slope, P: Physical, Sp: Speed, F: Function, V: Variation, L: Limit, K2: Calculus, K3: Calculus T1: Trigonometry, G1: Real World. X: No concept images

Table 8

Concept Images of Prospective Mathematics Teachers in the Second Stage Questions

Participants		Ö1	Ö2	Ö3	Ö4	Ö5	Ö6	Ö7
		Images						
The relationship between derivative-instantaneous change and slope	Instantaneous change	Universal	Point	Universal	Interval	Point	Point	X
	Slope	G1	G1?	K2	K3	T1/K3/K2	K2	X
	Derivative	V-R/R/L	G-S/R	G-V-L	G-V-R/L/F	G-V-L	G-V-F	X

V: Verbal, R: Ratio, G: Graphical, S: Slope, P: Physical, Sp: Speed, F: Function, V: Variation, L: Limit, K2: Calculus, K3: Calculus, T1: Trigonometry, G1: Real World. X: No concept images

The concept images of prospective primary school mathematics teachers in the first and second stage questions are given in Table 7 and Table 8. When the tables are analysed:

The concept images of pre-service elementary mathematics teachers about the relationship between these three concepts were determined. One of the noteworthy points about the findings of the analyses is that when the answers of the pre-service elementary mathematics teachers to the first stage questions (semi-structured interview questions) were examined, it was seen that the concept images they had were slightly less than the concept images they had in the second stage questions (application questions). In addition, in general, prospective elementary mathematics teachers were able to use the concept images they had in the first stage questions in the second stage questions. This situation was observed in participants Ö4 and Ö6 in the first grades and participants Ö1 and Ö3 in the second grades.

When the participants were asked about all concepts one by one, it was seen that they had concept images; however, they needed help to use their concept image cells effectively in explaining the relationship between concepts. This situation drew attention, especially in the first stage of the questions. On the other hand, prospective elementary mathematics teachers tried to use their concept images to show the relationship between concepts in general, especially in the second-stage questions. However, it was determined that they needed help using their concept images about the relationship between the concepts of derivative, slope, and instantaneous rate of change in the last question in the first and second stage questions. These difficulties were their expressions that these three concepts were the same. However, it was determined that they could not explain a relationship with the concept of rate of change, although they expressed that the concept of derivative was a slope calculation.

Mathematics Educators' Concept Images of the Relationship between Slope and Instantaneous Rate of Change with the Derivative

Concept images of mathematics educators are given in Table 9 and Table 10.

Table 9

Concept Images of Mathematics Educators in the First Stage Questions

Participants		ME1	ME2	ME3	ME4
The relationship between derivative-instantaneous change and slope	Instantaneous change	Global	Point	Point	Point
	Slope	G1/G2/C1/C2/D/G2	K1/K2	K1/K2	K3/K2
	Derivative	O	V-R-L	G-V-R/L	G-I-L

V: Verbal, R: Ratio, G: Graphical, S: Slope, P: Physical, O: Other, F: Function, V: Variation, L: Limit, D: Derivative, I: Intercept, K2: Calculus, K3: Calculus, T1: Trigonometry, G1: Real World, G2: Real World, C1: Algebra, C2: Algebra

Tablo 10

Concept Images of Mathematics Educators in the Second Stage Questions

Participants		ME1	ME2	ME3	ME4
The relationship between derivative-instantaneous change and slope	Instantaneous change	Global	Point	Point	Point
	Slope	G1/G2/C1/C2/D/G2	K1/K2	K1/K2	K3/K2
	Derivative	O	V-R-L	G-V-R/L	G-I-L

V: Verbal, R: Ratio, G: Graphical, S: Slope, P: Physical, O: Other, F: Function, V: Variation, L: Limit, D: Derivative, I: Intercept, K2: Calculus, K3: Calculus, T1: Trigonometry, G1: Real World, G2: Real World, C1: Algebra, C2: Algebra

In the interviews with mathematics educators, their concept images of slope, rate of change/instantaneous rate of change and derivative concepts were examined. It was seen that the fact that mathematics educators had different experiences caused a difference in their concept images. The shaping of Piaget's schemes on how concept images are differentiated based on experience supports this situation. It can be said that mathematics educators used the concept images they had in the interview questions in the first stage questions in the application questions in the second stage questions. In addition, ME2 is the lecturer responsible for Calculus 1, Calculus 2, and Calculus 3 courses of the pre-service elementary mathematics teachers who participated in the study. In this context, it can be said that the concept images of the pre-service elementary mathematics teachers in the study and the concept images of the participant ME2 are similar. Namely, pre-service elementary mathematics teachers and ME2 frequently used the statement "*when we think of derivative, we should think of slope.*" It was seen that they used the expression frequently.

Discussion and Conclusion

Mathematics educators' and pre-service elementary mathematics teachers' concept images about slope, rate of change/instantaneous rate of change and derivative concepts were determined by using Zandieh's (2000) concept images about derivative concept, Hauger's (1995) concept images about rate of change concept and Moore-Russo et al. (2011) analysis frameworks. This situation is reported in the findings by analysing each sub-problem of the study separately. A total of 7 pre-service elementary mathematics teachers, 3 of whom were studying in the first year and 4 of whom were studying in the second year, participated in the study. In addition, 4 lecturers working at different universities responsible for Calculus1, Calculus2 and Calculus3 courses took part in the study. ME2, one of the lecturers participating in the study, is responsible for the Calculus1, Calculus2 courses of the pre-service elementary mathematics teachers in the study. Considering the situations in the study, firstly, the results about the concept images of prospective elementary mathematics teachers were given. Then, the results of the concept images of mathematics educators, which is another case of the study, are given by supporting the studies in the literature.

When the results related to the concept images of pre-service elementary mathematics teachers about the relationship between the concepts of slope, rate of change and derivative were analysed, it was seen that the concept images of pre-service elementary mathematics teachers about these three concepts were generally predisposed to explain with the concept of derivative. The results of the interviews and application questions were that we are actually doing derivative calculations. However, when they were asked about the relationship between these three concepts, it was seen that they tended to use the statements that the geometric interpretation of the derivative is the slope and the physical interpretation of the derivative is the rate of change/instantaneous rate of change. Although they were more likely to use the concept images of the concept of derivative, it is known that when the concept of derivative is defined, the slope of the beam (secant) lines is approximated to the tangent and from here, the derivative is defined by the slope of the tangent with the help of the limit. However, it was observed that the students did not have any understanding and concept image about beam (secant) lines. These results are similar to the studies in the literature (Açıkyıldız & Gökçek, 2015; Amit & Vinner, 1990; Bingölbali & Monaghan, 2008; Erdoğan, 2017; Hart, 1991; Likwambe & Christiansen, 2008; Nayir, 2013; Orton, 1983; Ubuz, 1996, 2001, 2007). It can be said that the teaching of the derivative concept may be related to the classical calculus teaching (Breen et al., 1992; Doruk et al., 2018; Duru, 2006; Grover, 2015; Sağırlı et al., 2010) and especially the reduction of the Analyses 1 course hours. It is also obvious that this situation may be different in studies with different methods and techniques (see Çekmez & Baki, 2019; Ndlovu et al., 2011). Considering the studies conducted in different countries, the results of the study confirm that the concept of derivative is an epistemologically difficult concept as mentioned by Cornu (1991).

When the related literature is examined, it can be said that giving the definitions of concepts that require high-level mathematical knowledge (limit, continuity, derivative, etc.) in only two hours of theoretical lessons will not be sufficient for conceptual learning (Aksu, 2016; Bingölbali & Monaghan, 2008; Engin, 2016; Tall & Vinner, 1981; Vinner, 1983). In particular, it is thought that it will be important to include a concept such as the concept of derivative, which is considered as the building

block of the analysis course, in the minds of pre-service teachers in a more meaningful way (Engin, 2016; Gözen, 2001; Herman, 2002; Sağlam, 2011; Yeşildere, 2007). In addition, it is thought that it is important to clearly mention to the students that the concept of derivative has different representations and the relationships between these representations.

When the results related to the concept images of mathematics educators about the relationship between the concepts of slope, rate of change and derivative were analysed, it was seen that they tended to explain with the concept of derivative as stated in the results of prospective elementary mathematics teachers. When the statements and answers of the mathematics educators were examined, it was stated that "we actually examine the concept of derivative in these three concepts, we prepare the readiness of the concept of derivative". In addition, it was observed that the participants used dynamic geometry software while conveying the relationship between the concepts of slope, rate of change and derivative of ME1 and ME4 to the students. Similar to these results (Çekmez, 2013; Çekmez & Baki, 2019; Hart, 1991; Ndlovu et al., 2011; Öztoprakçı, 2014), it can be said that teaching the concept of derivative to students with dynamic geometry software helps students use concept images more effectively and internalise these concepts more. When the concept images of participant ME2 regarding the relationship between these three concepts are analysed, it can be said that he preferred to teach the concept of derivative to the students for the definition in calculus books. In addition, participant ME2 stated that it would not be beneficial for elementary mathematics teachers to use the field courses (Calculus1, Calculus2, Calculus3, Algebra, Abstract Mathematics etc.) that require high level knowledge in mathematics education in their future professional lives. This situation is similar to the findings of Kaymakçı et al. (2018). However, this situation is similar to the findings of basically you learn how to calculate with numbers, how to simplify algebraic expressions and calculate variables, how to reason about points, lines and shapes in the plane. The analysis includes these techniques and skills, but it also develops others at a finer and deeper level. Calculus, in fact, defines so many new concepts and numerical operations that you will not be able to learn everything you need in the classroom (Thomas & Finney, 2001).

When the results of the study are taken into consideration, the importance of the calculus course that requires high-level knowledge (Erol, 2013; Thomas & Finney, 2001) was in parallel with the study. From this point of view, it can be said that the concept images of prospective elementary mathematics teachers about the concept of slope, rate of change and derivative will not be clear.

Implications

In this study, the concept images of the participants about the concepts of slope, rate of change and derivative were determined. Prospective primary school mathematics teachers and mathematics educators were included in the study. In future studies, it can be considered important to include mathematics teachers in the participants as they use these three concepts in their professional lives. In this study, the concept of derivative and its sub-dimensions, which is the subject of Calculus 1 course, were examined. In the future, concept images of concepts in different content knowledge courses such as algebra, linear algebra, analytical geometry can be studied with different study groups.

Statement of Responsibility

The responsible author wrote the introduction, methods, findings and discussion, and finally the necessary conditions. The second author revised the introduction, discussion, conclusion and findings. Both authors contributed equally to the study.

Conflicts of Interest

There is no conflict of interest between the authors. The study, which was produced from the doctoral thesis of the responsible author, has the doctoral thesis supervisor as the second author.

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