Asya Studies

Akademik Sosyal Araştırmalar / Academic Social Studies

Year: 9, Number: 31, p. 1-24, Spring 2025

The Impact of Teachers' Technological Self-Efficacy on Gifted Technological Pedagogical Content Knowledge: A Case Study*

Üstün Yetenekliler Eğitiminde Öğretmenlerin Teknolojik Öz Yeterliklerinin Teknolojik Pedagojik Alan Bilgisine Etkisi: Bir Durum Çalışması

ISSN: 2602-2877 / E-ISSN: 2602-263X

Araştırma Makalesi
Research Article

Makale Geliş Tarihi
Article Arrival Date
14/01/2025

Makale Kabul Tarihi
Article Accepted Date
28/02/2025

Makale Yayım Tarihi
Article Publication Date
25/03/2025

Asya Studies

Dr. Öğr. Üyesi Zekai Ayık
Harran Üniversitesi
Özel Eğitim Bölümü
zekai.ayik@gmail.com
ORCID: 0000-0002-3562-6543

Dr. Öğr. Üyesi Muhammet Davut Gül
Tokat Gaziosmanpaşa Üniversitesi
Özel Eğitim Bölümü
mdavutgul1@gmail.com
ORCID: 0000-0003-0437-5865

*This study was carried out within the framework of the approval of Harran University Social Sciences and Humanities Ethics Committee dated 08/07/2024 and document number E-76244175-050.04-348695.

Abstract

This qualitative study explores the role of teachers' technological self-efficacy in integrating advanced tools, such as augmented reality (AR) and digital design software, into their instructional practices for gifted students. Through semi-structured interviews and classroom observations of three science teachers at a Science and Arts Center (SAC) in southeastern Turkey, the study examines the intersection of self-efficacy, technological pedagogical content knowledge (TPCK), and gifted education. This study employed a qualitative research design, specifically utilizing a case study approach. Thematic analysis revealed five key themes: (1) Technology Integration, highlighting the use of AR and digital tools to enrich learning experiences; (2) Impact on Learning, showing how technology increases student engagement and retention; (3) Teachers' Technological Self-Efficacy, demonstrating that teachers with higher self-efficacy were more confident in using and experimenting with technology; (4) Differentiated Instruction, emphasizing the role of technology in tailoring learning experiences for gifted students; and (5) Barriers and Challenges, identifying obstacles such as limited resources and insufficient professional development. The findings suggest that while technology has significant potential to enhance gifted education, there is a pressing need for ongoing training and institutional support to address barriers and strengthen teachers' technological competencies. The study provides practical recommendations for improving technology integration in education and advancing teachers' technological self-efficacy.

Keywords: Technological Self-efficacy, Gifted Education, Differentiation, Technology Integration, Augmented Reality

Öz

Bu nitel çalışma, öğretmenlerin artırılmış gerçeklik (AG) ve dijital tasarım yazılımı gibi gelişmiş araçları üstün yetenekli öğrencilere yönelik öğretim uygulamalarına entegre etmede teknolojik öz yeterliliklerinin rolünü araştırmaktadır. Çalışma, Türkiye'nin güneydoğusundaki bir Bilim ve Sanat Merkezi'nde (BİLSEM) görev yapan üç fen bilimleri öğretmeniyle yapılan yarı yapılandırılmış görüşmeler ve sınıf içi gözlemler aracılığıyla öz yeterlilik, teknolojik pedagojik içerik bilgisi (TPAB) ve üstün yeteneklilerin eğitiminin kesişimini incelemektedir. Bu çalışmada nitel bir araştırma tasarımı kullanılmış, vaka çalışması yaklaşımı benimsenmiştir. Tematik analiz beş ana temayı ortaya çıkarmıştır: (1) Öğrenme deneyimlerini zenginleştirmek için AG ve dijital araçların kullanımını vurgulayan Teknoloji Entegrasyonu; (2) Teknolojinin öğrenci katılımını ve kalıcılığını nasıl artırdığını gösteren Öğrenme Üzerindeki Etkisi; (3) Yüksek öz yeterliliğe sahip öğretmenlerin teknolojiyi kullanma ve deneme konusunda kendilerine daha fazla güvendiklerini gösteren Öğretmenlerin Teknolojik Öz Yeterliliği; (4) Üstün yetenekli öğrenciler için öğrenme deneyimlerini uyarlamada teknolojinin rolünü vurgulayan Farklılaştırılmış Öğretim; ve (5) Sınırlı kaynaklar ve yetersiz mesleki gelişim gibi engelleri tanımlayan Engeller ve Zorluklar. Bulgular, teknolojinin üstün yetenekliler eğitimini geliştirmek için önemli bir potansiyele sahip olmasına rağmen, engelleri ele almak ve öğretmenlerin teknolojik yeterliliklerini güçlendirmek için sürekli eğitim ve kurumsal desteğe acil ihtiyaç olduğunu göstermektedir. Çalışma, eğitimde teknoloji entegrasyonunun iyileştirilmesi ve öğretmenlerin teknolojik öz yeterliliklerinin geliştirilmesi için pratik öneriler sunmaktadır.

Anahtar Kelimeler: *Teknolojik Öz-yeterlilik, Üstün Yetenekliler Eğitimi, Farklılaştırma, Teknoloji Entegrasyonu, Artırılmış Gerçeklik*

Atıf Bilgisi / Citation Information

Ayık, Z., & Gül, M. D. (2025). The impact of teachers' technological self-efficacy on gifted technological pedagogical content knowledge: A case study. *Asya Studies*, *9*(31), 1-24. https://doi.org/10.31455/asya.1619664

INTRODUCTION

Gifted learners, distinguished by their exceptional aptitude in one or more areas, possess unique cognitive, emotional, and social characteristics (Baudson & Preckel, 2016; Davis et al., 2014). Modern interpretations of giftedness have shifted from solely emphasizing high intelligence to encompassing a broader view that prioritizes cultivating potential through supportive environments and opportunities for talent development (Gagné, 2013; Olszewski-Kubilius et al., 2016). Addressing the educational requirements of gifted individual's calls for tailored instructional methods that go beyond conventional teaching, with an emphasis on nurturing creativity, analytical thinking, and advanced problem-solving capabilities (Aljughaiman & Ayoub, 2012). In this respect, differentiation of curriculum elements serves as a cornerstone in addressing these unique needs (Tomlinson, 2017). By customizing the content, processes, outcomes, and learning environments, differentiation ensures alignment with learners' preparedness, interests, and individual profiles, thus promoting intellectual growth and autonomy in learning (Sayı & Yurtseven, 2022). Despite its importance, many educators encounter obstacles in effectively implementing differentiation, such as limited resources, inadequate professional development, and challenges in accommodating the diverse needs of gifted students (Çayır & Balcı, 2023; J. VanTassel-Baska & Stambaugh, 2005).

The incorporation of educational technologies (ET) offers a viable means to overcome these challenges (Yousef, 2021; Zengin et al., 2024). ET provide tools that foster more individualized and engaging educational experiences, enhancing differentiation by enabling exploration, collaboration, and dynamic learning opportunities. Research highlights that technology can support differentiated teaching practices by equipping educators to create tasks that are both appropriately rigorous and intellectually stimulating (Önal & Önal, 2021; Yıldırım et al., 2024). As such, technology not only complements teaching but also transforms it, paving the way for innovative approaches to unlocking the potential of gifted students (Çalişkan, 2017; Chen et al., 2013; Periathiruvadi & Rinn, 2012). ET, such as digital tools, learning management systems, and interactive software, offer transformative potential to enhance the educational experience for students across various levels (Cai et al., 2021; Li, 2024). Technology contributes to education by enriching learning environments, fostering collaboration, increasing engagement, and providing access to resources that would otherwise be unavailable. Digital platforms enable students to engage with interactive content, multimedia resources, and real-time feedback, enhancing the learning experience (Fei & Hung, 2016; Lavrysh, 2019). Furthermore, technologies facilitate personalized learning, allowing educators to cater to the diverse needs, interests, and abilities of their students. By supporting individualized learning pathways, technology ensures that each student can progress at their own pace, making education more inclusive and accessible.

In the context of gifted education, technology can play a pivotal role in supporting the advanced learning needs of exceptional students. Gifted learners often require more challenging and complex learning materials, and technologies can provide them with tools to explore deeper topics, engage in higher-level problem-solving, and develop critical thinking skills (Aljughaiman & Ayoub, 2012; Eysink et al., 2017). Studies have shown that integrating technology into the education of gifted children can significantly enhance their learning experiences by offering personalized tasks, encouraging creativity, and providing opportunities for independent learning. These technologies, when used effectively, not only enhance learning outcomes but also help educators meet the specific educational needs of gifted individuals (Mei et al., 2021).

Problem Statement

Gifted students' teachers' ability to use technology effectively is closely tied to their Gifted Technological Pedagogical Content Knowledge (GTPCK) competency (Mei et al., 2021). The GTPCK framework builds upon the Technological Pedagogical Content Knowledge (TPCK) model, which emphasizes the integration of three essential domains: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK) (Solissa et al., 2023). GTPCK adapts this model to meet the distinct needs of gifted learners by focusing on differentiation and personalization. However, the role of factors like "technological self-efficacy" in developing these competencies has not been thoroughly explored.

Technological self-efficacy refers to an individual's belief in their ability to use and integrate technology effectively within their teaching practices (Kent & Giles, 2017; Pan, 2020). For teachers working with gifted students, having high technological self-efficacy means they believe they can successfully use technological tools to enhance the learning experiences of their students. Teachers with high technological self-efficacy are more likely to adopt new tools and technologies, adapt them to meet the unique needs of gifted students, and overcome any challenges that arise during the integration process (Doğru et al., 2017). This study seeks to address the gap in research concerning the influence of technological self-efficacy on GTPCK competencies.

Related Research

Recent studies have investigated the integration of innovative technologies in the education of gifted children and the role of teachers' self-efficacy in enhancing their Technological Pedagogical Content Knowledge (TPCK) (Kent & Giles, 2017). One such study by (Yıldırım et al., 2024) focused on the impact of innovative practices designed for the educational needs of gifted children. The research involved 30 teachers from the Southeastern and Eastern Anatolia regions and employed a mixed-methods approach, including activities such as animations, augmented reality (AR), educational games, and STEAM. The findings highlighted that while teachers' attitudes towards technology use did not differ significantly by gender, the innovative practices had a positive impact on teachers' attitudes toward using technology in education. However, the study also noted that there were gaps in teachers' ability to adapt to technologies related to coding, engineering, and STEAM. This research suggests the importance of continuous professional development to ensure teachers can effectively integrate innovative technologies into their classrooms, particularly in enhancing the education of gifted children.

In addition, studies such as (Kaşçı & Selçuk, 2021; Kent & Giles, 2017; Solissa et al., 2023) examine the relationship between self-efficacy, motivation, and TPCK, which are essential for the professional development of teachers. Their research demonstrates that both self-efficacy and motivation significantly influence the development of TPCK in educators. Self-efficacy, defined as teachers' beliefs in their ability to successfully integrate technology into their teaching, is directly linked to their confidence in adopting new tools and methods. Motivation, on the other hand, plays a critical role in encouraging teachers to continuously develop their technological competencies, which in turn enhances their ability to integrate technology in the classroom effectively. Solissa et al. (2023) found that when teachers have higher self-efficacy and motivation, they are better equipped to integrate technology in ways that improve student outcomes, suggesting that fostering these traits is crucial for the successful implementation of innovative educational technologies.

Moreover, the importance of TPCK for effective technology integration in the classroom is supported by several studies. For instance, research by (Mishra & Koehler, 2006) define TPCK as the intersection of Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). The combination of these domains is crucial for educators to navigate the complexities of technology integration in their teaching practices. Sintawati (2019) emphasizes that teachers must develop TPCK competencies to integrate technology effectively into their lessons, while (Lavrysh, 2019) highlights that TPCK can foster a positive learning environment by facilitating better interaction among students and between educators and students.

Although these studies provide significant insights into the integration of technology in education, there is a gap in understanding the role of specific factors such as technological self-efficacy in shaping the TPCK competencies of teachers working with gifted students. The novelty of this research lies in exploring how technological self-efficacy influences teachers' ability to use augmented reality (AR) and other technologies to differentiate instruction for gifted learners. This study seeks to fill this gap by examining how self-efficacy impacts the integration of AR and other innovative technologies in teaching gifted students and how these technologies can better support differentiated instruction.

Research Objectives

The primary focus of this research is to explore how innovative technological practices, particularly in the areas of augmented reality (AR), can influence support classroom teachers' attitudes and competencies in using technology to meet the educational needs of gifted children. By understanding the impact of such activities, this study seeks to provide practical recommendations to improve teachers' technological self-efficacy and enhance the learning experiences of gifted students. The research objectives are:

- To examine how activities designed to teach innovative practices aimed at meeting the educational needs of gifted children impact teachers' attitudes toward technology integration in education.
- To evaluate the effectiveness of AR activities in enhancing teachers' ability to use technology in differentiated instruction for gifted students.
- To identify the specific challenges teachers face in integrating these innovative technologies into their classroom practices.

The integration of technology into the classroom, especially for gifted students, is essential to support their individualized learning needs and to maximize their potential. Gifted children often require more personalized and enriched learning experiences than the standard curriculum offers. Innovative technologies, such as AR, can help meet these needs by offering engaging, interactive, and differentiated learning opportunities (Önal & Önal, 2021). However, for these technologies to be effectively utilized, teachers must not only possess the necessary technological skills but also have positive attitudes toward the integration of such tools into their teaching practices (Pan, 2020).

Research has shown that teachers' technological self-efficacy—their confidence in using technology—plays a critical role in how they incorporate technology into their teaching (Solissa et al., 2023). Despite the potential benefits, many teachers still face challenges in adapting to new technologies, particularly in areas like STEAM (Gül & Ayık, 2023; Ülger & Çepni, 2020). This research is important because it will shed light on the specific factors that influence teachers' ability to adopt and effectively use technology to educate gifted children. Additionally, by focusing on teachers' attitudes and competencies, the study will offer insights into the support mechanisms and professional development opportunities necessary for educators to feel confident in using innovative technological tools.

The study will be guided by the following research questions:

1. Does the integration of innovative technology practices, such as AR, enhance teachers' self-efficacy in teaching gifted children?

2. What recommendations can be made to improve teachers' competence in using technology to support the learning of gifted children?

By addressing these questions, this research aims to contribute to the ongoing conversation about how to better equip teachers with the skills and confidence needed to incorporate technology effectively, particularly in the education of gifted children.

THEORETICAL FRAMEWORK

Gifted Students

Gifted students are individuals who demonstrate exceptional abilities or potential in one or more areas when compared to their peers (Davis et al., 2014). These talents can be seen in intellectual, creative, artistic, leadership, or specific disciplines such as mathematics or language (Gagné, 2013). Gifted students often possess advanced problem-solving skills, heightened creativity, and the ability to process information at a faster and deeper level than others (Kaufman & Sternberg, 2008). However, these exceptional abilities can present challenges in traditional educational settings, as gifted students may become disengaged, under-challenged, or frustrated when the curriculum does not meet their needs (VanTassel-Baska & Stambaugh, 2006). Without appropriate support, their motivation and academic performance may decrease, even causes talent losses (Godor, 2019). To nurture their intellectual development, it is essential to provide personalized and differentiated instruction that addresses their specific learning styles, interests, and emotional needs (Tomlinson, 1999).

The educational needs of gifted students are diverse and multifaceted. These students require more than just an accelerated curriculum—they need enrichment programs that go beyond the standard curriculum to offer more complex, stimulating tasks (Davis et al., 2014). Moreover, gifted students thrive in learning environments that promote creativity, critical thinking, and problem-solving skills. Innovative approaches, including the use of technologies such as augmented reality, can play a pivotal role in providing the challenges and engagement these students need (Önal & Önal, 2021). Education systems must evolve to offer specialized interventions and teaching strategies that recognize and cater to the unique abilities of gifted students, ensuring they are appropriately challenged, engaged, and supported throughout their educational journey (Sayı & Yurtseven, 2022).

Differentiation of Curriculum Elements: Addressing Learning Needs of Gifted Students

Differentiation is a crucial educational strategy designed to tailor instruction to meet the varied needs of students, ensuring that each student's unique abilities, strengths, and interests are addressed (Gül & Ayık, 2023). This approach is particularly important in mixed-ability classrooms, where students with different learning needs are present. Differentiation can be applied in several ways, such as varying the content, process, product, or learning environment (Tomlinson, 2017). Content differentiation involves adjusting what students are taught, offering more challenging materials and tasks suited to their individual levels. For gifted students, this might include providing advanced texts, tasks that require higher-order thinking, or projects that allow for deeper exploration (Reis et al., 2021).Process differentiation refers to the methods used for students to engage with the content. While some students might thrive with hands-on activities or collaborative learning, others may prefer independent research or self-paced tasks.

Product differentiation focuses on adjusting how students demonstrate their learning. Gifted students, for example, can be encouraged to create more complex projects or solve problems in innovative ways, fostering their creativity and independent thinking. Finally, learning environment differentiation involves modifying the classroom setting, whether physical or virtual, to better support diverse learning styles. The incorporation of technology can offer a more engaging and effective environment for gifted learners (Mei et al., 2021; Periathiruvadi & Rinn, 2012). As such, effective differentiation in the classroom is essential for gifted students, as it ensures they are continually challenged and provided with opportunities to develop their potential, ultimately fostering their academic growth and engagement.

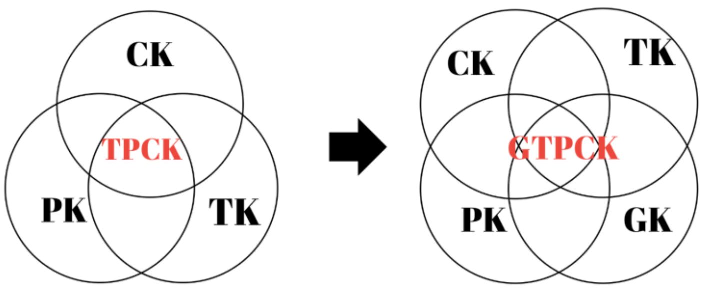
Enhancing Gifted Education through Technology Integration

The integration of technology into education has reshaped traditional teaching methodologies, and this shift is particularly impactful in the context of gifted education. Gifted students, who demonstrate exceptional abilities in various domains, require specialized instruction that goes beyond traditional methods to meet their advanced cognitive, emotional, and social needs (Baudson & Preckel, 2016; Reis et al., 2021). The TPCK (Technological Pedagogical Content Knowledge) framework, which emphasizes the intersection of technology, pedagogy, and content knowledge, provides a guide for teachers to effectively integrate technology into their teaching practices (Mishra & Koehler, 2006). For gifted education, TPCK supports teachers in designing instruction that blends technological tools with appropriate pedagogical strategies to foster advanced learning (Mei et al., 2021). In this context, differentiated instruction plays a key role, where technology is used to modify content, processes, products, and learning environments to cater to the diverse needs of gifted students. Technology tools can be used to facilitate advanced problem-solving, creativity, and critical thinking, which are essential for gifted students (Yıldırım et al., 2024). However, the effective implementation of TPCK requires that teachers not only have access to digital tools but also the pedagogical skills to align these tools with their content and students' needs (Lavrysh, 2019).

GTPCK: Gifted Technological Pedagogical Content Knowledge

Building upon the TPCK framework, GPCTK (Gifted Pedagogical Content Technological Knowledge) is a knowledge framework specifically designed for teachers of gifted education, integrating Gifted Knowledge (GK) with Pedagogical (PK), Content (CK), and Technological Knowledge (TK) (See Figure 1). Unlike TPCK (Technological Pedagogical Content Knowledge), which focuses on the integration of technology in general education, GPCTK emphasizes the unique cognitive, emotional, and developmental needs of gifted students.This model ensures that teachers not only use technology effectively but also understand the specialized pedagogical and content knowledge required to nurture gifted learners. The GTPCK competency emphasizes the integration of technology into differentiated instruction for gifted learners (Mei et al., 2021). GTPCK expands upon TPCK by embedding strategies specifically designed for gifted education, ensuring that technology use is purposeful and strategic to meet the unique learning profiles of gifted students (Mei et al., 2021). This competency equips teachers with the knowledge and skills to use advanced technologies like AR, coding platforms, and digital design tools to foster creativity, problem-solving, and critical thinking (Önal & Önal, 2021). GTPCK supports the creation of personalized and enriched learning experiences by allowing teachers to differentiate content and products, thus promoting innovation and deeper understanding (Sommerauer & Müller, 2018). However, the success of GTPCK in gifted education depends heavily on teachers' ability to adapt to technological advancements and to incorporate continuous professional development programs that enhance their technological and pedagogical skills (Sihanita et al., 2024). These programs are essential for equipping teachers with the knowledge needed to align technology with the educational needs of gifted learners, ensuring that ET is used effectively to promote engagement, motivation, and cognitive growth (Chen et al., 2013; Periathiruvadi & Rinn, 2012).

Figure 1: TPCK and GTPCK



Technological Self-Efficacy

One factor which may affect teachers’ GTPCK competency can be their beliefs in use of technology. In this respect, the term self-efficacy can be considered as an important factor that is a concept rooted in Albert Bandura’s social cognitive theory (Bandura, 1977), and it refers to individuals' beliefs about their ability to perform specific tasks and achieve goals.

Bandura defines it as the conviction that one can successfully execute the courses of action required to deal with prospective situations. Self-efficacy influences how people approach challenges and tasks, shaping their motivation, emotional responses, and behavior. Research shows that individuals with high self-efficacy tend to show greater persistence, effort, and resilience, leading to better performance in various tasks (Tschannen-Moran et al., 1998). On the other hand, individuals with low self-efficacy may avoid tasks or give up easily, impacting their performance and overall success (Zimmerman, 2000)

Technological self-efficacy, specifically, refers to an individual’s belief in their ability to effectively use and integrate technology in various contexts. It plays a crucial role in technology adoption, particularly in education (Kent & Giles, 2017). Teachers' beliefs about their technological abilities influence how they incorporate technology into their teaching practices (Jimoyiannis & Komis, 2006). For instance, research by (Moore-Hayes, 2011) suggests that teachers' technology self-efficacy strongly correlates with their actual use of technology in teaching. Teachers with higher technological self-efficacy are more likely to integrate technology into their classrooms, whereas those with lower efficacy might struggle to utilize technological tools effectively.

Technological self-efficacy is closely tied to TPCK (Technological Pedagogical Content Knowledge), a framework that emphasizes the intersection of three key components of knowledge: technological knowledge (TK), pedagogical knowledge (PK), and content knowledge (CK). Teachers with higher technological self-efficacy are more likely to develop robust TPCK, as they feel more confident in using technology to support teaching and enhance student learning across various subject areas (Kaşçı Tuğçe & Selçuk, 2021; Kent & Giles, 2017) Studies have shown that self-efficacy and motivation significantly impact TPCK (Solissa et al., 2023), underlining the importance of building both confidence and competence in teachers’ technology use to improve their pedagogical approaches.

For example, classroom teachers’ technological pedagogical content knowledge has been found to be positively correlated with their self-efficacy beliefs, indicating that teachers who believe in their ability to use technology effectively also tend to demonstrate stronger integration of technology in their teaching (Kaşcı & Selçuk, 2021). Therefore, fostering technological self-efficacy is essential in developing the necessary skills for effective technology integration in teaching, ultimately enhancing both teaching quality and student outcomes.

Technological self-efficacy plays a crucial role in developing GTPCK (Gifted Technological Pedagogical Content Knowledge) by influencing how confidently teachers integrate technology into gifted education. Since GTPCK extends TPCK by adding Gifted Knowledge (GK), teachers with high technological self-efficacy are more likely to use advanced digital tools, adaptive learning systems, and AI-driven platforms to support the unique cognitive and emotional needs of gifted students. Confident teachers can effectively implement differentiated instruction, acceleration models, and creativity-enhancing technologies, whereas those with low self-efficacy may struggle to integrate these tools. Research shows that self-efficacy strongly correlates with TPCK development, meaning that fostering teachers’ belief in their technological abilities can significantly enhance their capacity to create engaging, innovative, and personalized learning experiences for gifted students. Therefore, strengthening technological self-efficacy is essential for ensuring meaningful technology integration in gifted education, ultimately improving both teaching effectiveness and student outcomes.

METHOD

Research Design

This study employed a qualitative research design, specifically utilizing a case study approach. The case study method is suitable for addressing the research questions focused on understanding how teachers integrate educational technologies (ET) and differentiated instruction for gifted learners, while reflecting their technological self-efficacy. (Yin, 2018) identifies three conditions that justify the use of a case study: a focus on "how" and "why" inquiries, minimal researcher control over participants' behaviors, and an examination of contemporary phenomena within real-life contexts. The phenomenon of interest in this study is the technological self-efficacy of teachers of gifted students who are expected to integrate technologies in to differentiation practices to foster talent development of gifted students and address their special educational needs. The case study design allowed for triangulation through multiple data sources, such as interviews and classroom observations, offering a deeper exploration of how teachers integrate ET and differentiated instruction, reflecting their technological self-efficacy. This approach enabled a comprehensive understanding of the challenges and successes faced by teachers in integrating technology into their instructional practices.

The research procedure followed a clear and structured process to ensure systematic data collection and analysis. Three science teachers from a Science and Arts Center (SAC) in southeastern Turkey were purposively selected based on their experience with technology integration and willingness to incorporate Augmented Reality (AR) into their teaching practices. Data collection occurred in two phases: Phase 1 involved semi-structured interviews, which provided insights into the teachers' technological self-efficacy and their integration of AR in teaching gifted students. Phase 2 consisted of classroom observations, where three science teachers were observed during lessons on specific science topics, and field notes were taken on their use of AR and instructional strategies. Data from both interviews and observations were analyzed using thematic analysis with the assistance of MAXQDA software, and triangulation was employed to validate the findings across the multiple data sources. Ethical approval was obtained from the relevant institutional review board (Harran University Social Sciences Ethical Committee), and participants were fully informed of the study's objectives and procedures. Written consent was obtained from all participants, ensuring their anonymity through the use of pseudonyms, and all data were kept confidential. Teachers were also made aware that their participation was voluntary, and they could withdraw from the study at any time.

Participants

The participants in this study were three science teachers, selected based on their experience with integrating technology into their classrooms and their willingness to incorporate Augmented Reality (AR) into their teaching practices. In this study, purposive sampling was employed to select teachers with at least five years of experience and varying levels of self-efficacy in AR integration. The teachers informed about the research before the data collection and volunteerism principle was employed. These teachers were chosen to ensure variability in teaching practices and perspectives on technology integration. All participants teach gifted students, which provided a unique context for exploring the integration of advanced teaching tools like AR to support higher-order learning skills. The participants had varying years of teaching experience and backgrounds. They were all full-time staff members at the participating school, the Science and Arts Center (SAC), located in southeastern Turkey. The primary demographic details of the participants include their teaching experience, age, and subject specialization in gifted education (see Table 1). The teachers were diverse in their professional experience, with some having formal training in gifted education and others relying on experience and informal development opportunities.

Table 1: Participants' Demographic Profiles

Name	**Gender**	***Age***	**Years of experience**	**Branch**	**Training in Gifted Education**
Ali	Male	44	18	Science	In-service
Sare	Female	31	5	Science	In-service
Fahriye	Female	34	9	Science	In-service

Data Collection

The data collection process was divided into two primary phases: semi-structured interviews and classroom observations. The first phase of data collection involved conducting semi-structured interviews with the participating teachers. These interviews were designed to gather in-depth insights into teachers' beliefs, perceptions, and self-efficacy regarding technology use and differentiation. Each interview lasted between 30 and 40 minutes and was conducted in a quiet, private setting. The interviews were audio-recorded with participants' consent and transcribed for later analysis. The questions focused on:

- Teachers' technological self-efficacy and their perceptions of technology's impact on student learning.
- Specific experiences of integrating AR in the classroom and its effects on differentiation.
- Efforts made by teachers to enhance their technological competencies in teaching gifted students.

The second phase involved classroom observations over a period of three weeks. Total duration was 120 minutes for all lessons. Each teacher was observed once during their science lessons on topics such as "Leaf Structure", "Planets", and "Rockets". The observations focused on:

- How the teachers integrated AR technology into their lessons.
- The pedagogical strategies used and how they aligned with differentiation practices.

- The interactions between teachers and students, as well as any challenges or successes in using AR.

The primary researcher took detailed field notes during the observations, recording the use of AR technology, teaching strategies, and student engagement. The researcher remained a passive observer during these sessions to minimize interference with the teaching process. Interviews were conducted based on a protocol consisting of 10 open-ended questions developed by the researcher (Appendix 1). For classroom observations, a structured observation form was utilized to systematically assess teachers' technology integration processes (Appendix 2).

Data Analysis

Thematic analysis was employed to analyze the data collected through semi-structured interviews (Braun & Clarke, 2006) and classroom observations, following a systematic multi-step coding process. The analysis aimed to identify patterns and themes related to teachers' technological self-efficacy, differentiation strategies, and barriers to technology integration.

Thematic Analysis Process

Data analysis followed Braun & Clarke's (2006) six-phase thematic analysis framework, ensuring rigor, transparency, and reproducibility. The process was conducted using MAXQDA software, which facilitated systematic coding and categorization:

Familiarization with Data – Interview transcripts and observation field notes were reviewed multiple times to gain an in-depth understanding of teachers' perspectives and classroom practices. Initial notes were taken to highlight recurring ideas and concepts.

Generating Initial Codes (Open Coding) – A total of 65 unique codes emerged through line-by-line coding of interview transcripts, focusing on key ideas such as "Technological Self-Efficacy," "AR Integration," and "Differentiation Practices." Codes were tagged to relevant text segments for further refinement.

Searching for Themes (Axial Coding) – The generated codes were grouped into broader categories, such as "Factors Influencing Technological Self-Efficacy" and "Challenges in AR Integration." Links between codes were examined to identify relationships and patterns.

Reviewing Themes – Themes were refined and cross-checked against both interview data and observation field notes to ensure internal consistency and alignment with the research objectives.

Defining and Naming Themes (Selective Coding) – The final five core themes were identified, including:

- Technological Self-Efficacy and Teacher Confidence
- Differentiation Strategies Using AR
- Barriers to AR Integration in Gifted Education
- Institutional and Professional Development Factors
- Student Engagement and AR-Enhanced Learning

Producing the Report – The finalized themes were synthesized into findings, illustrating teachers' experiences with AR technology and differentiation strategies.

Integration of the GTPCK Framework in Analysis

The GTPCK (Gifted Technological Pedagogical Content Knowledge) framework was applied during axial and selective coding to assess how teachers integrated technological, pedagogical, and content knowledge in gifted education. Specifically:

Technological Knowledge (TK) – Examined how teachers selected and used AR tools, their confidence in using technology, and their ability to troubleshoot technical issues.

Pedagogical Knowledge (PK) – Analyzed teaching strategies for differentiation, instructional techniques, and adaptability to students' learning needs.

Content Knowledge (CK) – Assessed how AR was used to enhance subject-specific learning, such as in science topics like "Leaf Structure" and "Planets."

Gifted Knowledge (GK) – Investigated whether teachers differentiated instruction effectively for gifted students, considering their unique cognitive and emotional needs.

Classroom observations were coded using the GTPCK framework, allowing for systematic evaluation of teachers' real-time technology integration, differentiation strategies, and student-teacher interactions. For example, themes such as "AR as a Tool for Engagement" and "Differentiation through Technology" emerged, highlighting successful practices and challenges.

To ensure validity and reliability, triangulation was conducted by comparing interview findings with classroom observations. Any discrepancies between teachers' stated beliefs and actual classroom practices were analyzed, providing deeper insights into the factors influencing GTPCK competency. Additionally, ethical considerations were upheld throughout the analysis. Pseudonyms were used to protect participants' anonymity, and member checking was conducted, allowing participants to review and validate data interpretations, ensuring accuracy and fairness in representing their experiences.

Validity and Reliability

To ensure the validity and reliability of the study, several strategies were employed. Triangulation was used by incorporating multiple data sources, namely interviews and observations, which allowed for cross-checking and validation of the findings. The study employed data triangulation, comparing findings from semi-structured interviews with classroom observations. Additionally, interview transcripts were shared with participants for validation, ensuring accuracy and credibility. Member checking was implemented by inviting participants to review the interview transcripts and the researcher's interpretations, ensuring the accuracy and validity of the data. Consistency in data collection was maintained as all interviews and observations were conducted by the same researcher, which helped ensure uniformity in the data collection procedures. Additionally, the use of MAXQDA software for coding and analyzing the data improved the reliability of the analysis by facilitating a systematic approach to identifying patterns and themes.

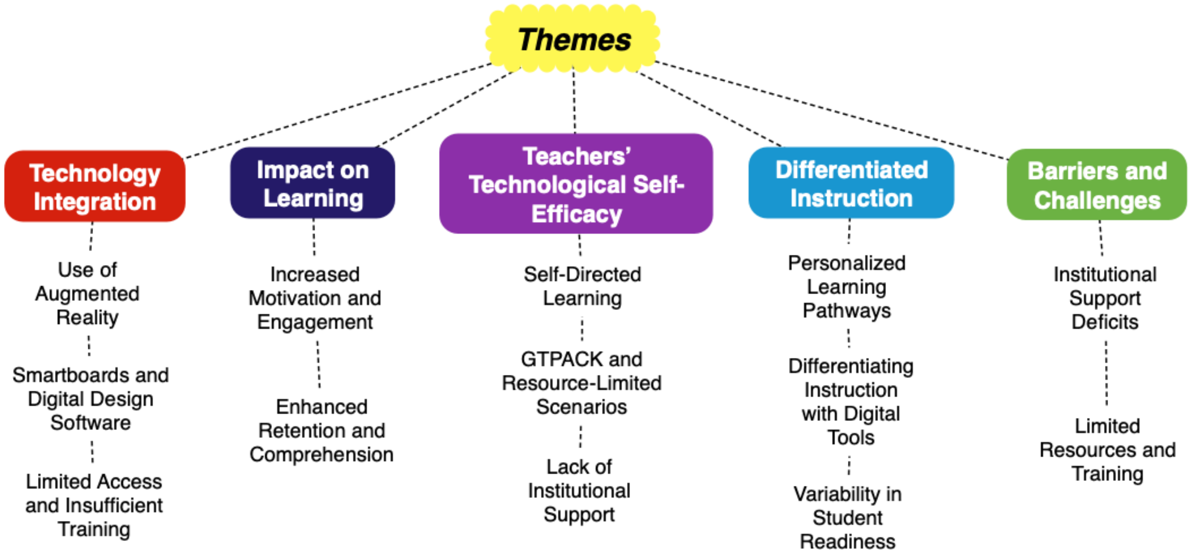
Declaration of the Ethics Committee

Committee Name: Harran University Social Sciences and Humanities Ethics Committee
Date: 08.07.2024
Document Number: E-76244175-050.04-348695

FINDINGS

The findings of this study explore the key themes that emerged from the thematic analysis of teacher interviews and classroom observations. These themes shed light on the role of teachers' technological self-efficacy in integrating advanced tools into their instructional practices, within the context of GTPCK. Figure 1 displays the thematic map that illustrates the key themes and sub-themes identified through the thematic analysis of teacher interviews and classroom observations, highlighting the central role of teachers' technological self-efficacy in integrating technology into their practices.

Figure 2: Thematic Map



Technology Integration

A central theme of the findings was the integration of technology into teaching, particularly in the context of gifted education. Teachers viewed technology as a critical tool for enhancing classroom practices, enabling them to provide more engaging, interactive, and differentiated learning experiences for gifted students.

Use of Augmented Reality (AR)

Teachers in the three lessons mostly utilized AR to make abstract scientific concepts more accessible and engaging. For instance, Fahriye described using AR to create immersive lessons on planetary systems, allowing students to visualize planets in three dimensions, which greatly enhanced their understanding of complex topics.

Smartboards and Digital Design Software

In addition to AR, smartboards and design software such as Geogebra and SketchUp were highlighted as essential tools for fostering creativity and improving problem-solving skills. Sare noted that with smartboards, students could solve significantly more problems in a single lesson compared to traditional teaching methods, improving the efficiency of teaching and learning.

Limited Access and Insufficient Training

Many teachers reported challenges related to access to advanced technological resources. Furthermore, insufficient institutional training programs hindered their ability to fully integrate these tools into their teaching practices. Ali shared, "We're expected to integrate advanced tools like AR, but without proper training, it feels overwhelming.

Impact on Learning

The impact of technology on students' learning, particularly in terms of engagement, motivation, and retention, emerged as another significant theme. Teachers highlighted the positive effects of technology on student learning outcomes.

Increased Motivation and Engagement

Teachers reported that interactive technologies like AR and digital design software significantly increased student engagement and motivation. Fahriye explained, "When I used AR to demonstrate planetary systems, students were fascinated and could retain information more effectively. It made science come alive for them."

Enhanced Retention and Comprehension

The interactive and hands-on nature of these technologies was noted to improve students' retention of concepts. Teachers observed that students grasped complex topics more readily when they could manipulate and engage with digital simulations repeatedly. Classroom observations further supported these findings. Teachers used AR to simulate real-world conditions, such as the external factors affecting plant leaves. These immersive activities helped students explore scientific phenomena in ways that traditional teaching methods could not.

Technological Self-Efficacy

Teachers' confidence in using technology was a recurrent theme influencing the effectiveness of its integration. Technological self-efficacy played a crucial role in how well teachers could incorporate new tools into their teaching practices.

Self-Directed Learning

Many teachers acknowledged the importance of self-directed learning in developing their technological skills. Sare shared, "I often rely on YouTube tutorials to learn new software because structured training is not readily available." This indicated that many teachers took the initiative to learn new technologies on their own.

GTPCK and Resource-Limited Scenarios

Teachers who were confident in their technological abilities demonstrated a strong understanding of how to apply GTPCK in classroom settings with limited resources. For example, one teacher described using AR tools in a resource-poor environment, relying on available mobile devices to create an enriching learning experience for students.

Lack of Institutional Support

Teachers with lower self-efficacy often struggled to integrate complex tools into their teaching, citing a lack of professional development and support. Ali and Sare noted, "We are expected to use these tools, but without proper training, it feels like an overwhelming task." These findings underscore the importance of fostering technological self-efficacy through professional development programs and institutional support.

Differentiated Instruction

The ability to tailor instruction to meet the diverse needs of gifted learners was another key theme that emerged from the data. Technology was frequently used as a means to differentiate instruction and cater to students' individual learning profiles.

Personalized Learning Pathways

Teachers used AR tools to personalize learning experiences. For example, Fahriye explained how AR could be tailored to meet the needs of different learners, saying, "For visual learners, AR provided an engaging way to interact with content, while for analytical students, the same tool could be used to deepen problem-solving skills."

Differentiating Instruction with Digital Tools

Digital design software like SketchUp was used to support students with specific talents, such as digital drawing or coding. Teachers were able to design tasks that catered to individual strengths, allowing gifted students to explore their abilities in greater depth.

Variability in Student Readiness

Despite the benefits, teachers acknowledged challenges in implementing differentiated instruction. Ali expressed concern about the difficulty in aligning AR tools with students' varying readiness levels. "It's difficult to tailor AR tools to students at different stages of readiness," the teacher remarked. However, teachers generally agreed that technology helped bridge gaps by offering more flexible learning experiences.

Barriers and Challenges

While teachers recognized the potential of technology to transform gifted education, several barriers and challenges were identified that hindered the full integration of these tools into their instructional practices.

Institutional Support Deficits

Many teachers expressed frustration with the lack of institutional support for technology integration. Sare stated, "There's always something new to learn, but never enough time to master it." Teachers pointed out that adequate professional development and training were crucial for maximizing the effectiveness of technology in the classroom.

Limited Resources and Training

Teachers also noted that access to advanced technology was often limited. Sare emphasized the emotional toll of these barriers, saying, "It’s disheartening to know what’s possible with technology but feel unable to implement it fully due to lack of resources." These barriers highlight the need for institutional reforms to provide greater support, access to resources, and continuous professional development for teachers.

The findings of this study emphasize the transformative role that technology, particularly AR and digital design tools, can play in enhancing gifted education. These tools were shown to foster increased motivation, engagement, and retention among students, while also enabling differentiated instruction tailored to individual learning needs. However, the study also identified significant barriers, including limited access to technology, insufficient professional development opportunities, and the need for greater technological self-efficacy among teachers. Addressing these barriers through targeted training programs, resource allocation, and institutional support will be key to maximizing the potential of technology in gifted education. Fostering a culture of continuous learning and experimentation among educators will also be essential for overcoming these challenges and unlocking the full potential of technological integration in the classroom.

DISCUSSION AND CONCLUSION

This study reveal critical insights into the integration of advanced technology tools, such as AR and digital design software, in gifted education. The key focus of the research, teachers' technological self-efficacy, emerged as a central determinant in the successful implementation of technology-enhanced teaching methods. This section will handle the implications of the findings, drawing on previous research to highlight the contributions of this study while acknowledging its limitations and suggesting areas for future research.

One of the most prominent findings of this study is the critical role of teachers' technological self-efficacy in their ability to integrate advanced tools such as AR into their teaching practices. This aligns with previous studies that emphasize the importance of teacher confidence in using technology to enhance classroom experiences (Moore-Hayes, 2011). Teachers who exhibited high levels of self-efficacy were more likely to experiment with new technologies, such as AR, and integrate them into their lessons effectively. These teachers often relied on self-directed learning through online resources such as YouTube tutorials, demonstrating an intrinsic motivation to improve their technological competencies. As observed by Bandura (1997), individuals with higher self-efficacy are more likely to exist in the face of challenges and take on tasks that require the acquisition of new skills.

Conversely, teachers with lower self-efficacy were hesitant to use complex technologies, fearing failure or disruption in the classroom. This finding resonates with previous research by (Ertmer, 2005), which suggests that a lack of confidence in one's ability to use technology effectively can be a significant barrier to its integration in the classroom. The findings underscore the need for professional development programs aimed at enhancing teachers' technological self-efficacy, particularly in environments where teachers may not have access to formal training (Hew & Brush, 2007).

The use of technology, especially AR, was found to be particularly effective in meeting the unique needs of gifted learners. The ability of AR tools to make abstract scientific concepts more tangible and interactive helped to engage students and foster a deeper understanding of complex topics, such as planetary systems and plant biology. This finding is consistent with research by (Önal & Önal, 2021), who arguea that immersive learning environments created by technologies like AR can enhance students' motivation and engagement by providing them with opportunities to explore content in a hands-on and interactive manner. Moreover, AR's ability to support experiential learning and problem-solving aligns with (Vygotsky, 1978) socio-cultural theory, which posits that learners can achieve higher levels of cognitive development through guided interaction with tools that extend their thinking.

However, despite the positive impact of AR on learning, teachers also identified barriers related to technology access and inadequate training. Similar concerns have been highlighted in previous studies, which indicate that institutional support, including access to resources and professional development, plays a crucial role in successful technology integration (NAGC, 2021). The lack of consistent access to advanced technologies and ongoing professional development opportunities was a recurrent challenge faced by teachers, limiting the extent to which they could fully exploit the potential of AR and other advanced tools. This finding suggests that in order to maximize the benefits of technology, schools and policymakers must invest in the necessary infrastructure and support systems.

The positive effects of technology on student engagement, motivation, and retention are consistent with the broader literature on technology-enhanced learning. Teachers in this study noted that AR tools, in particular, contributed to greater student motivation and enhanced retention of information. These findings support the work of (Önal & Önal, 2021), who asserts that interactive and visual technologies can make abstract concepts more concrete, thus improving student comprehension and long-term retention. The ability of AR to transform traditional lessons into immersive, hands-on experiences helps students engage in deeper, more meaningful learning, which is essential for gifted learners who often require more challenging and stimulating activities.

Additionally, the study found that technology facilitated differentiated instruction, enabling teachers to tailor learning experiences to individual students' needs. This is in line with the research of (Tomlinson, 2017), who advocates for the use of technology in differentiation, as it allows for flexible learning pathways that address students' diverse needs. For example, AR tools were used to engage visual learners, while other tools helped analytical students deepen their problem-solving skills. However, challenges related to aligning technology with varying levels of student readiness and learning styles were also noted. These challenges highlight the importance of ongoing professional development in ensuring that teachers can effectively leverage technology for differentiation.

While the potential of technology to enhance teaching and learning is widely acknowledged, this study also uncovered several barriers that hinder the effective integration of technology in classrooms. The most significant of these barriers were related to institutional support deficits, limited access to resources, and a lack of adequate professional development. These findings are consistent with prior research, which has identified institutional barriers as a major obstacle to successful technology integration.

Teachers in this study highlighted the frustration of being expected to integrate advanced tools like AR without adequate training or support. This mirrors the findings of previous studies, such as that by (Yıldırım et al., 2024) which emphasize the importance of providing teachers with adequate professional development opportunities to build their technological competencies. Furthermore, teachers often reported that they had to rely on self-directed learning to acquire new skills, which was time-consuming and sometimes inefficient. This points to the need for more structured professional development programs that are specifically tailored to the needs of educators in resource-limited environments.

This study explored the critical role of teachers' technological self-efficacy in the integration of advanced technologies, such as Augmented Reality (AR), in gifted education. The findings highlight that teachers who possess higher levels of technological self-efficacy are more confident and effective in incorporating AR and other digital tools into their instructional practices. However, the study also identified significant barriers to technology integration, including limited access to resources, inadequate training opportunities, and the lack of ongoing institutional support. These challenges prevent teachers from fully realizing the potential of technology in their classrooms and underscore the need for targeted professional development and structural support to address these gaps. By providing teachers with the necessary tools, training, and institutional encouragement, schools can maximize the impact of technology on learning outcomes for gifted students. Furthermore, the study emphasized the importance of differentiated instruction, where technology plays a crucial role in personalizing learning pathways and addressing the diverse needs of gifted learners. Despite challenges, such as aligning technology with varying learning styles, the integration of AR and other tools was seen as an effective strategy to create dynamic and flexible learning environments.

In conclusion, the integration of technology in gifted education holds transformative potential, but to fully harness its benefits, a comprehensive approach is required—one that includes building teachers' technological self-efficacy, ensuring equitable access to resources, and providing ongoing professional development. By overcoming these barriers, educators can create more engaging and personalized learning experiences that allow gifted students to reach their full potential, preparing them for future challenges and opportunities in an increasingly digital world.

This study has several limitations that should be seen when interpreting the findings. First, the sample size was small, consisting of three teachers from a single Science and Arts Center (SAC) in southeastern Turkey, which limits the generalizability of the results to a broader population of teachers or schools in different contexts. The study also focused on gifted students, meaning the findings may not apply to mainstream classrooms or other educational settings with different technological resources and teaching challenges. Additionally, the reliance on self-reported data from interviews may have introduced bias, as participants might have portrayed themselves more favorably or may not have fully recognized all aspects of their technological self-efficacy.

Moreover, the study was constrained by its limited scope, particularly in its exploration of broader institutional and policy factors influencing technology integration. While barriers like lack of institutional support were noted, systemic influences such as educational policies and curriculum frameworks were not thoroughly explored. The focus was also on specific tools like AR and digital design software, which may not represent the full range of technologies teachers use. Lastly, the study’s short duration limited the ability to observe long-term changes in teachers' technological self-efficacy. Future research with a larger, more diverse sample and a longer time frame could provide more comprehensive insights into the long-term impact of technology integration and the role of institutional support.

Based on the findings and limitations of this study, several recommendations can be made to improve technology integration in gifted education, particularly addressing the barriers teachers face, such as lack of institutional support and insufficient professional development opportunities.

There is a strong need for ongoing, structured professional development programs tailored to the specific needs of teachers integrating advanced technologies like AR and digital design tools. These programs should not only focus on technical training but also emphasize pedagogical strategies for differentiation, student engagement, and effective integration into lesson plans for gifted learners. To ensure meaningful professional growth, institutions should implement:

Tiered Professional Development: A differentiated approach where teachers can progress at their own pace, with training modules ranging from basic AR tool usage to advanced curriculum design using digital technologies.

Peer Mentorship Programs: Experienced teachers with strong technological self-efficacy could mentor less confident colleagues, fostering a collaborative learning culture.

Hands-on Workshops and Micro-Credentialing: Institutions could offer practical, application-based training where teachers experiment with AR tools in real lesson settings. Micro-credentialing in AR integration could incentivize participation.

Institutional support is critical in creating an environment where teachers feel confident and empowered to integrate technology. Schools and administrators should:

Ensure Access to Up-to-Date Technology: Schools should invest in updated AR tools, reliable internet infrastructure, and technical support staff to minimize barriers to implementation.

Create Professional Learning Communities (PLCs): Schools should establish regular collaboration forums where teachers share best practices, challenges, and innovative AR applications in gifted education.

Time Allocation for Technology Training: Schools should allocate designated time within teachers' schedules for technology training and collaborative lesson planning, reducing the burden of self-learning outside work hours.

Future studies should expand the sample size and explore a wider variety of educational contexts to gain a broader perspective on technology integration challenges. Longitudinal research could provide deeper insights into how sustained professional development impacts teachers' technological self-efficacy and the long-term effects on student learning outcomes in gifted education. By addressing these barriers with practical, scalable solutions, institutions, policymakers, and educators can work collaboratively to enhance the integration of advanced technologies, ultimately improving both teacher confidence and student learning experiences in gifted education.

Acknowledgments

The authors would like to express sincere gratitude to all participants who generously shared their time, experiences, and insights, which were invaluable to the success of this research.

Author Contribution

The authorship contribution of the research is 55% for the first author and 45% for the second author.

Declaration of the Ethics Committee

Committee Name: Harran University Social Sciences and Humanities Ethics Committee

Date: 08.07.2024

Document Number: E-76244175-050.04-348695

REFERENCES

Aljughaiman, A. M., & Ayoub, A. E. A. (2012). The effect of an enrichment program on developing analytical, creative, and practical abilities of elementary gifted students. *Journal for the Education of the Gifted, 35*(2), 153–154. https://doi.org/10.1177/0162353212440616

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191–215.

Baudson, T. G., & Preckel, F. (2016). Teachers' conceptions of gifted and average-ability atudents on achievement-relevant Dimensions. *Gifted Child Quarterly, 60*(3), 212–225. https://doi.org/10.1177/0016986216647115

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Cai, S., Liu, C., Wang, T., Liu, E., & Liang, J. C. (2021). Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. *British Journal of Educational Technology, 52*(1), 235–251. https://doi.org/10.1111/bjet.13020

Çalişkan, E. (2017). An investigation of teachers' views on the use of information technologies in the training of talented and gifted pupils. *Gazi University Gazi Faculty of Education Journal*, *37*(3), 811–833. https://doi.org/https://doi.org/10.17152/gefad.330149

Çayır, A., & Balcı, E. (2023). The effect of differentiated instruction on gifted students critical thinking skills and mathematics problem solving attitudes. *Educational Research and Reviews*, *18*(12), 392–398. https://doi.org/10.5897/err2023.4375

Chen, J., Yun Dai, D., & Zhou, Y. (2013). Enable, enhance, and transform: How technology use can improve gifted education. *Roeper Review*, *35*(3), 166–176. https://doi.org/10.1080/02783193.2013.794892

Davis, G. A., Rimm, S. B., & Siegle, D. (2014). *Education of the gifted and talented* (6th ed.). Pearson.

Doğru, M., Şeren, N., & Koçulu, A. (2017). Investigation of classroom teachers' self-efficacy perceptions regarding technology use in terms of various variables. *Eurasian Journal of Researches in Social and Economics*, *4*(12), 464–472.

Ertmer, P. A. (2005). Teacher pedagogical beliefs: The final frontier in our quest for technology integration? *ETR&D*, *53*(4), 25–39.

Eysink, T. H. S., Hulsbeek, M., & Gijlers, H. (2017). Supporting primary school teachers in differentiating in the regular classroom. *Teaching and Teacher Education*, *66*, 107–116. https://doi.org/10.1016/j.tate.2017.04.002

Fei, V. L., & Hung, D. (2016). Teachers as learning designers: What technology has to do with learning. A view from singapore. *Educational Technology*, *56*(4), 26–29.

Gagné, F. (2013). The dmgt: Changes within, beneath, and beyond. *Talent Development & Excellence*, *5*(1), 5–19.

Godor, B. P. (2019). Gifted metaphors: Exploring the metaphors of teachers in gifted education and their impact on teaching the gifted. *Roeper Review*, *41*(1), 51–60. https://doi.org/10.1080/02783193.2018.1553219

Gül, M. D., & Ayık, Z. (2023). Enrichment studies in gifted education: A bibliometric analysis with rstudio. *Participatory Educational Research*, *10*(3), 266–284. https://doi.org/10.17275/per.23.55.10.3

Hew, K. F., & Brush, T. (2007). Integrating technology into K-12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, *55*(3), 223–252. https://doi.org/10.1007/s11423-006-9022-5

Kaşçı Tuğçe, & Selçuk, G. (2021). Examination of classroom teachers' technological pedagogical content knowledge and teacher self-efficacy beliefs. *Journal of Educational Technology and Online Learning*, *4*(4), 774–792. https://doi.org/10.31681/jetol.1018879

Kaufman, S. B., & Sternberg, R. J. (2008). Conceptions of giftedness. In S. I. Pfeiffer (Ed.), *Handbook of Giftedness in Children* (pp. 71–93). Springer.

Kent, A. M., & Giles, R. M. (2017). Preservice teachers' technology self-efficacy. *SRATE*, *26*(1).

Kuckartz, U., & Rädiker, S. (2019). *Analyzing Qualitative Data with MAXQDA*. Springer.

Lavrysh, Y. (2019). Effective integration of educational technologies in terms of TPCK framework at technical university. *International Journal of Pedagogy Innovation and New Technologies*, *6*(2), 33–39. https://doi.org/doi:10.5604/01.3001.0013.6824

Li, T. (2024). The influence of information technologies on creative and critical thinking of students. *Cultura y Educacion*, *36*(3), 571–601. https://doi.org/10.1177/11356405241268982

Mei, S., Leng, P., Dai, X., Li, Z., & Ma, Z. (2021). Teacher knowledge and skill for gifted and talented education. 2021(5). www.converter-magazine.info

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/https://doi.org/10.1111/j.1467-9620.2006.00684.x

Moore-Hayes, C. (2011). Technology integration preparedness and its influence on teacher--efficacy. *Canadian Journal of Learning and Technology*, *37*(3).

NAGC. (2021). Competencies for teachers: gifted and talented, Grades K-12.

Olszewski-Kubilius, P., Subotnik, R. F., & Worrell, F. C. (2016). Aiming talent development toward creative eminence in the 21st century. *Roeper Review*, *38*(3), 140–152. https://doi.org/10.1080/02783193.2016.1184497

Önal, N. T., & Önal, N. (2021). The effect of augmented reality on the astronomy achievement and interest level of gifted students. *Education and Information Technologies*, *26*(4), 4573–4599. https://doi.org/10.1007/s10639-021-10474-7

Pan, X. (2020). Technology acceptance, technological self-efficacy, and attitude toward technology-based self-directed learning: Learning motivation as a mediator. *Frontiers in Psychology*, *11*. https://doi.org/10.3389/fpsyg.2020.564294

Periathiruvadi, S., & Rinn, A. N. (2012). Technology in gifted education: A review of best practices and empirical research. *Journal of Research on Technology in Education*, *45*, Issue 2, pp. 153–169. https://doi.org/10.1080/15391523.2012.10782601

Reis, S. M., Renzulli, S. J., & Renzulli, J. S. (2021). Enrichment and gifted education pedagogy to develop talents, gifts, and creative productivity. *Education Sciences*, *11*(10). https://doi.org/10.3390/educsci11100615

Sayı, A. K., & Yurtseven, N. (2022). How do gifted students learn? Their learning styles and dispositions towards learning. *Education 3-13*, *50*(8), 1031–1045. https://doi.org/10.1080/03004279.2021.1929380

Sihanita, Y. K., Priambodo, A., & Tuasikal, A. R. S. (2024). TPCK (Technological Pedagogical and Content Knowledge) competence for educator: A literature review. EDUKASIA: *Jurnal Pendidikan Dan Pembelajaran*, *5*(2), 77–92. https://doi.org/10.62775/edukasia.v5i2.851

Solissa, M. E., Maq, M. M., Aldina, F., & Wantu, M. H. (2023). Technological pedagogical content knowledge (TPCK): An overview through self-efficacy and motivation to become a professional teacher. *Edumaspul-Journal of Education*, *7*(2), 2562–2571.

Tomlinson, C. A. (1999). *The differentiated classroom: responding to the needs of all learners.* Upper Saddle River, NJ.

Tomlinson, C. A. (2017). *How to differentiate instruction in academically diverse classrooms* (3rd ed.). ASCD.

Tschannen-Moran, M., Hoy, A. W., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202–248. https://doi.org/10.3102/00346543068002202

Ülger, B. B., & Çepni, S. (2020). Gifted education and STEM: A thematic review. *Journal of Turkish Science Education, 17*(3), 443–467. https://doi.org/10.36681/tused.2020.38

VanTassel-Baska, J. L., & Stambaugh, T. (2006). *Comprehensive curriculum for gifted learners* (3rd ed.). Pearson Education.

VanTassel-Baska, J., & Stambaugh, T. (2005). Challenges and possibilities for serving gifted learners in the regular classroom. *Theory into Practice, 44*(3), pp. 211–217. https://doi.org/10.1207/s15430421tip4403_5

Vygotsky, L. (1978). Mind in Society. In M. Cole, V. John-Steiner, S. Scribner, & E. Souberman (Eds.), Mind in society: The development of higher pedagogical proceses. Harvard University Press.

Yıldırım, P., Alan, B., & Yıldız, S. (2024). The impact of innovative technological practices for gifted children's education on support classroom teachers' attitudes and opinions towards technology use. *Theoretical Education, 17*(4), 849–872. https://doi.org/10.30831/akukeg.1477823

Yin, R. K. (2018). *Case study research and applications: design and methods.* Sage.

Yousef, A. M. F. (2021). Augmented reality assisted learning achievement, motivation, and creativity for children of low-grade in primary school. *Journal of Computer Assisted Learning, 37*(4), 966–977. https://doi.org/10.1111/jcal.12536

Zengin, S., Çolak, N., Akel, E., Ay, Z. Ö., Çolak, A., & Metin, E. (2024). Teachers' views on the use of technology in education. *International Journal of Social and Humanities Sciences Research, 11*(3), 165–173. https://doi.org/10.5281/zenodo.10616592

Zimmerman, B. J. (2000). Self-efficacy: an essential motive to learn. *Contemporary Educational Psychology, 25*(1), 82–91. https://doi.org/10.1006/ceps.1999.1016

APPENDIX 1: INTERVIEW PROTOCOL

Introduction

"Thank you for participating in this study. This interview aims to explore your experiences and perceptions regarding the use of AR technology in teaching gifted students. Your responses will remain confidential. You may skip any question you are uncomfortable answering."

Interview Questions

1. How confident do you feel using technology in your teaching?
2. What types of digital tools such as AR technologies have you used in your classroom?
3. Can you describe a specific instance where you successfully integrated technology into a lesson?
4. How do you think technology impacts student engagement and differentiation?
5. What challenges have you faced when incorporating technology into your lessons?
6. Have you received any formal training on technology such as AR integration? If so, how helpful was it?
7. How do you assess the effectiveness of technology-based teaching strategies?

8. What support or resources would help you feel more confident in using technology?
9. How do students generally respond to technology-enhanced lessons compared to traditional methods?
10. What recommendations do you have for improving technology integration in gifted education?

APPENDIX 2: CLASSROOM OBSERVATION PROTOCOL

Observation Guidelines

Each observation will last 45 minutes.

The researcher will remain a passive observer to avoid influencing classroom dynamics.

Observations will focus on AR integration, differentiation strategies, and student-teacher interactions.

Structured Observation Form

Category	**Notes**
Lesson Topic	(e.g., Leaf Structure, Planets, Rockets)
Technology Used	(e.g., AR apps, smartboards, simulations)
Teacher’s Role	(Instructor, facilitator, observer)
Student Engagement	(High, moderate, low)
Challenges Noted	(Technical issues, student difficulties, etc.)
Successes Observed	(Student enthusiasm, deeper learning, collaboration)
Additional Notes	(Any unexpected observations)