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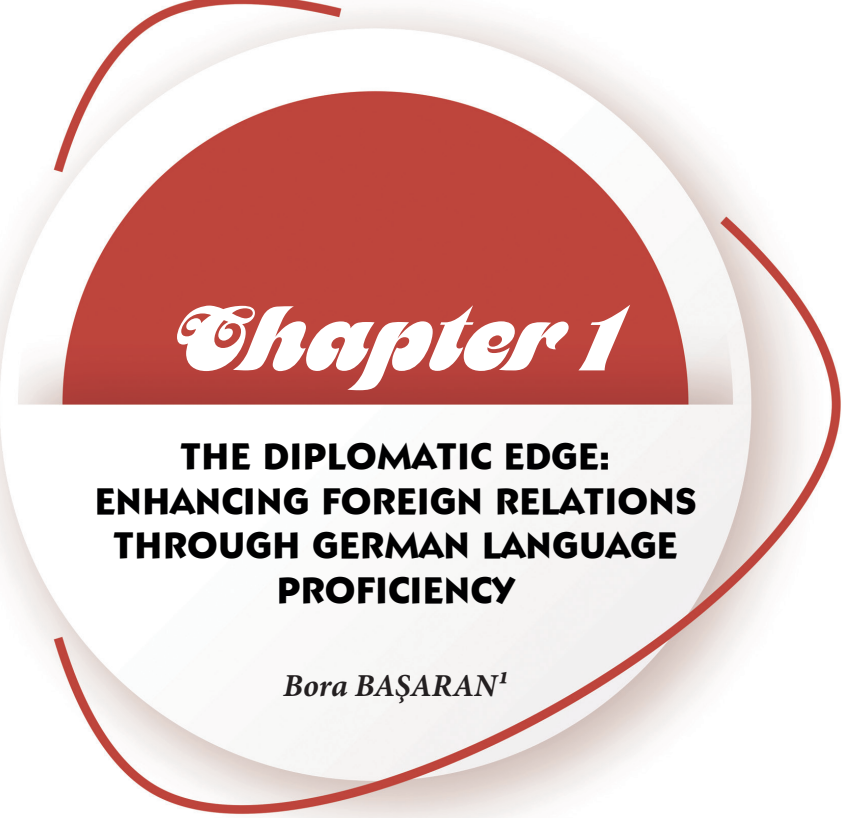
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Chapter 1

THE DIPLOMATIC EDGE: ENHANCING FOREIGN RELATIONS THROUGH GERMAN LANGUAGE PROFICIENCY

Bora BAŞARAN¹

1 Assoc. Prof. Dr., Anadolu University, Faculty of Education, Department of Foreign Language Education, bbasran@anadolu.edu.tr, Orcid: 0000-0003-0251-5895

INTRODUCTION

Learning a foreign language goes beyond mastering vocabulary and grammar; it's a key to unlocking cultural nuances, fostering mutual understanding, and bridging divides. For diplomats, the proficiency of foreign language skills holds a distinct significance. It's not just about communication, but also about navigating the subtleties of international relations, building trust, and facilitating nuanced negotiations. Mastery in a foreign language enables diplomats to engage more deeply, understand contexts better, and forge stronger connections, making it an indispensable tool in the realm of diplomacy.

This chapter explores the importance of German language proficiency in enhancing foreign relations, specifically focusing on its impact on diplomatic communication, cultural understanding, and economic cooperation. It also examines the role of educational institutions and government policies in promoting German language learning. Drawing on empirical research and case studies, this chapter provides comprehensive insights into the benefits of German language proficiency for individuals, organizations, and nations in the context of international relations.

Language proficiency plays a crucial role in diplomatic communication, enabling effective and nuanced exchanges between diplomats from different nations. Furthermore, language proficiency fosters cultural understanding, which is essential for building strong diplomatic ties. Proficiency in the German language allows diplomats to gain a deeper understanding of German culture, traditions, and values. Studies highlight the positive relationship between language proficiency and national identification among immigrants in Germany (Hochman & Davidov, 2014).

Language proficiency positively affects national identification, contributing to a stronger sense of belonging and cultural integration. In terms of economic cooperation, Germany is a major global economic player, and proficiency in the German language opens doors to business opportunities, trade partnerships, and investment collaborations (Laversuch, 2008; Streitwieser et al., 2015). To promote German language proficiency, educational institutions, and government policies play a vital role. Educational institutions provide language courses, cultural immersion programs, and exchange opportunities that facilitate language learning. Government policies can support language education by allocating resources, incentivizing language learning initiatives, and fostering partnerships between educational institutions and diplomatic organizations.

The German language proficiency is of immense importance in enhancing foreign relations. It facilitates effective diplomatic communication, promotes cultural understanding, and strengthens economic cooperation. Educational

bodies and government strategies contribute to play a crucial role in promoting German language learning. By investing in language education and fostering language proficiency, individuals, organizations, and nations can gain a significant diplomatic edge in the realm of international relations (Christian et al., 2005; Grenier, 2015; Hubackova, 2017).

Language plays a crucial role in diplomacy and international relations as it facilitates effective communication and cultural understanding. These are essential for building strong diplomatic ties and fostering economic cooperation between nations (Golan, 2013). In the realm of diplomacy, an adept diplomat possesses not only domain-specific expertise but also a profound mastery of foreign languages, essential tools for global communication.

A distinguished envoy in international relations and diplomatic translations must be equipped to engage in intricate negotiations with foreign dignitaries; conduct insightful discussions cognizant of prevailing economic trends; deliberate on financial and geopolitical matters; confidently present at meetings, diplomatic forums, and international conferences; and discerningly select the most fitting cultural and discursive approach tailored to the specific nuances of intercultural dialogues (Khalel et al., 2021; Kyrda-Omelian et al., 2022).

Proficiency in the German language can facilitate diplomatic communication, promote cultural exchange, and strengthen economic partnerships (Golan, 2013). Effective diplomatic communication requires language skills that enable diplomats to engage in meaningful conversations, negotiate agreements, and resolve conflicts. Language proficiency allows diplomats to convey nuanced messages accurately and build trust with their counterparts (Šimunjak & Caliandro, 2019). Cultural understanding is another crucial aspect of foreign relations, and proficiency in the German language enables diplomats to gain a deeper understanding of German culture, traditions, and values. This understanding fosters mutual respect and appreciation, leading to stronger diplomatic relations.

In this particular chapter, an in-depth exploration of the existing literature concerning German language proficiency tailored for diplomats has been undertaken. Based on this exploration, preliminary insights and considerations have been gathered and presented. These insights are intended to serve as a foundational base for designing more comprehensive and detailed research studies in the future, further elucidating the significance and intricacies of German language proficiency in the field of diplomacy.

1. LANGUAGE PROFICIENCY FOR DIPLOMATS

In the context of international relations, language proficiency plays a crucial role in diplomatic negotiations and interactions. Proficiency in the language of

the host country allows diplomats to navigate cultural nuances, understand local customs, and build rapport with their counterparts (Khrystiuk et al., 2021). This understanding fosters effective communication and facilitates the resolution of conflicts through diplomatic channels.

Several studies have found a positive correlation between language proficiency and diplomatic success, with diplomats fluent in the host country's language reporting more effective negotiations (Olshtain et al., 1990). Language proficiency is a key attribute that significantly impacts diplomatic success in various domains (Olshtain et al., 1990).

In the context of international student adjustment and cross-cultural relations, language proficiency is considered a vital factor in the transition to living in a new country and integrating socially with locals (Wilson & Komba, 2012). Additionally, language proficiency, particularly English proficiency, is frequently mentioned as a crucial factor in academic achievement among international students (Wilson & Komba, 2012).

The importance of language proficiency in diplomatic success can be attributed to its role in effective communication and understanding. When diplomats are proficient in the language of the host country, they can better grasp the subtleties, cultural nuances, and unspoken norms that are essential for successful negotiations and collaborations (Olshtain et al., 1990). This proficiency enables diplomats to establish meaningful connections and build relationships based on mutual understanding and respect, which are fundamental in diplomacy (Olshtain et al., 1990).

Furthermore, language proficiency facilitates empathy in language, allowing diplomats to bridge cultural gaps and foster mutual respect (Olshtain et al., 1990). By understanding the language and cultural references of the host country, diplomats can demonstrate their willingness to engage with the local culture and society, which can lead to more compassionate and constructive dialogues (Olshtain et al., 1990). Trust, a crucial component of successful diplomacy, is also cultivated through direct communication without translation, creating a more personal connection and an appreciation for the host country's culture, history, and social norms (Olshtain et al., 1990).

Language proficiency plays a vital role in diplomatic success by enabling effective communication, understanding, empathy, and trust-building (Olshtain et al., 1990). Diplomats who are fluent in the language of the host country have a significant advantage in negotiations and collaborations, as they can navigate complex situations with greater ease and establish deeper connections with their counterparts (Olshtain et al., 1990). The positive correlation between language proficiency and diplomatic success highlights the importance of investing in language education and training for diplomats to enhance their effectiveness in international relations (Olshtain et al., 1990).

The concept of soft power argues that influence can be achieved through attraction and persuasion. Language proficiency plays a crucial role in effective communication and understanding, which are essential for successful persuasion and influence (Chaiken, 1979). When diplomats have proficiency in the tongue of the host country, they can better connect with the local population and build rapport, which enhances their persuasive abilities (Chaiken, 1979). Research has shown that attractive communicators are often perceived as more persuasive, and physical attractiveness can influence opinions and attitudes (Chaiken, 1979). However, it is important to note that attractiveness alone may not be sufficient for persuasion, and expertise and supporting arguments are also important factors (Maddux & Rogers, 1980).

Language proficiency contributes to the overall success of diplomatic efforts by promoting cultural exchange and understanding. Diplomats who possess language skills can engage in meaningful conversations with local communities, gaining insights into their perspectives and fostering mutual understanding (Grincheva, 2015). This cultural understanding is crucial for building trust and establishing long-term diplomatic relationships. In conclusion, language proficiency plays a vital role in effective diplomatic communication and international relations. It enables diplomats to engage in meaningful conversations, negotiate agreements, and resolve conflicts. Language proficiency also contributes to information disclosure in corporate governance and promotes cultural exchange and understanding. By investing in language learning and fostering language proficiency, diplomats can enhance their effectiveness in international relations.

The correlation between language proficiency and diplomatic success highlights the importance of investing in language education and training for diplomats (Gilboa, 2008). By improving language proficiency, diplomats can enhance their ability to attract and persuade, ultimately contributing to their effectiveness in international relations and diplomacy.

Language proficiency is a complex skill that goes beyond basic communication and plays a crucial role in human interactions, particularly in international relations and diplomacy (Sawir et al., 2012). It involves not only understanding words and sentences but also grasping the subtleties, idioms, cultural references, and unspoken norms that give language depth and richness (Sawir et al., 2012). In the context of German, proficiency in the language is especially significant due to Germany's influential position in global politics, economics, and culture (Sawir et al., 2012).

2. THE SPEECH ACT THEORY

A common perspective segregates words from actions. However, words, in their essence, can also be actions. As illustrated by the Speech Act theory

(Leilei, & Chunfang, 2023), words not only catalyze actions but many times, they are actions themselves.

This conception of language as a dynamic action holds paramount importance in diplomacy. It underscores that diplomatic conversations and exchanges aren't merely instrumental; they can be pivotal in their own right. In diplomacy, actions often manifest through words. Recognizing the potency of language in this context is imperative.

The Speech Act theory propels us to differentiate between the act of verbal expression, the intent behind the expression, and the results emanating from it. The theory also demarcates direct speech acts – characterized by definitive phrases like 'hereby' or explicit declarations like 'I promise' – from indirect speech acts, where a speaker's motive is derived from the context (Hanna, & Richards, 2019).

Effective diplomatic communication requires a deep understanding of the language and culture of the host country. Language proficiency enables diplomats to engage in meaningful conversations, negotiate agreements, and resolve conflicts (Ang et al., 2015). Proficiency in the language of the host country allows diplomats to gain insights into the local culture, customs, and values, facilitating better communication and building rapport with their counterparts (Stefanidou et al., 2022). This cultural understanding helps diplomats navigate sensitive topics, avoid cultural faux pas, and establish trust, essential for successful diplomatic relations. Furthermore, language proficiency contributes to effective corporate governance. This also shows the importance of language planning in cultural diplomacy and its impact on higher education (Wheeler, 2013). Language proficiency enables diplomats to convey information accurately, ensuring messages are understood in their intended context and minimizing the risk of miscommunication.

3. LANGUAGE PROFICIENCY IN GERMAN

In the context of diplomacy, language proficiency in German can enhance the soft power of German-speaking nations, particularly in European and global contexts (Winkler & Nye, 2005). Germany's influential position in politics, economics, and culture makes proficiency in the German language even more significant (Winkler & Nye, 2005). By speaking the language fluently, diplomats can establish a deeper connection with German-speaking counterparts, understand cultural nuances, and effectively navigate complex negotiations (Winkler & Nye, 2005). Being proficient in German goes beyond simply speaking the language; it enables individuals to connect with German-speaking nations on a deeper level. This understanding fosters more effective communication, allowing diplomats, like businesspeople, and other professionals to navigate complex negotiations and collaborations with

German-speaking counterparts (Sawir et al., 2012).

Empathy in language, the ability to put oneself in another's shoes, can bridge cultural gaps and foster mutual respect, leading to more compassionate and constructive dialogues (Li et al., 2018). Trust, a fundamental component of successful diplomacy, is cultivated through direct communication without translation, creating a more personal connection and an appreciation for German culture, history, and social norms (Li et al., 2018).

Proficiency in the German language opens doors to deeper engagement with German-speaking nations, enhancing understanding, empathy, and trust-building in diplomatic and international relations (Sawir et al., 2012). It enables individuals to establish meaningful connections and build relationships based on mutual understanding and respect. This proficiency is particularly important in international settings where effective communication and cultural sensitivity are essential for successful collaboration and cooperation (Sawir et al., 2012).

For instance, considering economic cooperation, Germany is a major global economic player, and proficiency in the German language opens doors to business opportunities, trade partnerships, and investment collaborations (Guo et al., 2017). Research by Guo et al. (2017) highlights the importance of English language proficiency in international exchanges, as English is the most frequently used language in various sectors, including diplomacy, finance, trade, and industry. Similarly, proficiency in the German language can facilitate effective business negotiations, understanding legal frameworks, and navigating market dynamics, thereby promoting economic growth and bilateral trade (Isphording, 2013).

International Organizations: German-speaking diplomats have played key roles in the EU and other international bodies, reflecting the ongoing relevance of the German language in diplomatic circles (Bulmer, & Paterson, 2010; Helwig, 2019). Proficiency in German allows diplomats to actively participate in discussions, negotiations, and decision-making processes within these organizations. By being able to communicate directly in German, diplomats can effectively represent their countries' interests and contribute to diplomatic efforts.

Educational institutions provide language courses, cultural immersion programs, and exchange opportunities that facilitate language learning (Sefotho, 2022). Government policies can support language education by allocating resources, incentivizing language learning initiatives, and fostering partnerships between educational institutions and diplomatic organizations (Golan, 2013). Research from Peláez & Echeverri (2022) underscores the need to move beyond an instrumentalized perception of language for competitiveness and instead recognize the cultural and cognitive benefits of language learning.

The correlation between language proficiency and diplomatic success highlights the importance of investing in language education and training for diplomats (Gilboa, 2008). By improving language proficiency, diplomats can enhance their ability to attract and persuade, ultimately contributing to their effectiveness in international relations and diplomacy.

4. SPECIALIZED LANGUAGE EDUCATION FOR DIPLOMATS

Time constraints pose a significant challenge for diplomats when it comes to language training. Diplomatic work is often demanding and time-consuming, leaving diplomats with limited availability for language learning. As a result, specialized language training programs are necessary to accommodate the unique needs and time constraints of diplomats.

One study by Meinzer et al. (2005) examined the efficacy of a short-term, intensive language training program called Constraint-Induced Aphasia Therapy (CIAT). This program, grounded in learning principles such as mass practice and shaping, aimed to improve language functions in chronic aphasia patients. The study found that short-term intense language training, like CIAT, can lead to substantial and lasting improvements in language functions. The use of family and friends in the training was also found to be valuable.

Language education initiatives play a vital role in providing language courses, cultural immersion programs, and exchange opportunities (O'Rourke et al., 2016). Government policies can support language learning by allocating resources, incentivizing language education, and fostering partnerships between educational institutions and diplomatic organizations (O'Rourke et al., 2016).

In the US, a growing demand exists for an increasing demand for language skills, with more job postings requiring bilingual candidates (O'Rourke et al., 2016). Language learning is also prioritized in K-12 education, with many states having foreign language requirements or options for fulfilling elective graduation requirements through language study. Additionally, language proficiency assessments, such as the ACTFL Oral Proficiency Interview – Computer (OPIc), are used in hiring, advancement, and certification decisions in various sectors.

Language proficiency is a significant predictor of overall proficiency in a foreign language (Sparks et al., 1997). In a study by (Sparks et al., 1997), end-of-year grades in the foreign language and foreign language word decoding were identified as the best predictors of overall proficiency. This suggests that not only the ability to comprehend and produce language but also the decoding of words in a foreign language plays a crucial role in achieving proficiency.

Moreover, the differentiation between Cognitive Academic Language Proficiency (CALP) and Basic Interpersonal Communicative Skills (BICS) has been proposed to explain the variation in language proficiency and language use among different social classes (Olshtain et al., 1990). CALP refers to the academic type of language proficiency, while BICS refers to interpersonal communication skills. The interdependence hypothesis suggests that proficiency in both CALP and BICS is important for successful language learning and communication (Olshtain et al., 1990).

The language of diplomacy necessitates specialized vocabulary and cultural understanding. Proficiency in the language used in diplomatic contexts is crucial for effective communication and successful negotiations (Wheeler, 2013). Diplomats need to be able to navigate the intricacies of diplomatic discourse, which often involves specialized terminology and protocols. Understanding the cultural nuances and context-specific communication styles is also essential for building rapport and establishing trust with counterparts from different countries (Wheeler, 2013).

Investing in language education and promoting language learning initiatives can have broader societal benefits beyond economic cooperation. Language proficiency fosters cultural understanding, which plays a pivotal role in fostering successful diplomatic relations and enhancing cross-cultural collaboration. It allows diplomats to comprehend the nuances of German culture, traditions, and values, leading to mutual respect and appreciation. Furthermore, policies in language education that emphasize preserving local languages alongside foreign language learning can help preserve linguistic diversity and indigenous knowledge.

For diplomatic language training, tailor-made programs can be developed to optimize the limited time available for diplomats. These programs should focus on intensive language instruction, targeting the specific language skills required for diplomatic negotiations and interactions. By customizing the curriculum to cater to diplomats, these specialized programs can provide efficient and effective language learning opportunities.

CONCLUSION

In an increasingly interconnected world, the importance of effective communication in diplomacy cannot be overstated. Central to this communication is the role of language proficiency, and in the context of European and global diplomacy, German stands out as a significant player. The pages preceding this conclusion have highlighted the multifaceted benefits of mastering the German language, especially for those involved in international relations and diplomacy.

Germany, as one of the world's major economic powerhouses, holds a critical position in both European and global affairs. For diplomats, proficiency in the German language not only facilitates smoother negotiations but also provides deeper insights into the nuances of German culture, tradition, and values. By understanding the cultural context, diplomats can navigate sensitive discussions more effectively, leading to more productive outcomes and fostering mutual respect between nations.

Moreover, the benefits of German language proficiency extend beyond the immediate realm of diplomacy. As highlighted earlier, the business world also reaps the rewards of effective communication. Germany's strong economic position means that proficiency in the language can unlock a plethora of business opportunities, trade partnerships, and investment collaborations. In a world where global trade dynamics are constantly evolving, having the linguistic tools to navigate these shifts can provide a significant edge.

However, the benefits of language proficiency, particularly in German, aren't limited to economic and diplomatic circles alone. In a broader societal context, language acts as a bridge, connecting diverse cultures and promoting mutual understanding. Proficiency in a foreign language, in this case, German, fosters a deeper appreciation of cultural differences, breaking down barriers and dispelling biases. This cultural exchange, facilitated by language, enriches societies by introducing new perspectives and fostering a spirit of global camaraderie.

The emphasis on specialized language training for diplomats is particularly noteworthy. Given the unique demands and time constraints of diplomatic work, traditional language learning methods might not always be effective. Tailor-made programs that focus on the specific needs of diplomats, emphasizing intensive instruction and cultural immersion, can lead to more rapid and comprehensive language acquisition. Such initiatives underline the importance nations place on effective diplomacy and signify a commitment to fostering international relations built on understanding and trust.

Additionally, the broader implications of language education policies cannot be ignored. By prioritizing the maintenance of local languages alongside foreign language learning, societies can preserve their linguistic diversity and indigenous knowledge. In an era of globalization, where there's a risk of languages becoming extinct and cultural identities getting diluted, such policies play a pivotal role in safeguarding a nation's heritage.

In conclusion, while the digital age has introduced a myriad of tools to aid communication, the human element remains irreplaceable. True understanding and effective diplomacy hinge on more than just words; they require a deep appreciation of context, culture, and tradition. German language proficiency, as discussed, offers a gateway to this understanding,

enhancing diplomatic relations and paving the way for fruitful international collaborations. As the world continues to evolve, the importance of language in diplomacy will remain constant, reminding us of our shared humanity and the bridges we can build through communication.

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Chapter 2

SELF-EFFICACY OF PRE-SERVICE SCIENCE TEACHERS IN SCIENCE LABORATORY USE AND TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE

Duygu METİN PETEN¹

Zeynep DURAK²

Buse DİRLİK³

1 Associate Professor, Ege University, Department of Mathematics and Science Education,
ORCID 0000-0002-4704-8605, duygu.metin.peten@ege.edu.tr

2 Science Teacher, Ministry of National Education

3 Science Teacher, Ministry of National Education

Introduction

The twenty-first century embodies great changes and advances in different fields. These advances take place in many fields such as science, art, economy, and technology. These developments cause new requirements to arise in the education system, especially in science education. A good understanding of today's world, which is shaped by science and technology from different angles, is only possible by comprehending what science is and being able to think and act scientifically. For this reason, in many countries in the last few years, the general aim of science education has been emphasized as “raising science literate citizens” (AAAS, 1990, 1993; NRC, 1996) and science education is considered as one of the most indispensable parts of today's education system (NRC, 2010). The major aim of science education in this context is to create a learning environment where students can comprehend how science operates, how scientific knowledge is organized, and how evidence is supported, as well as understand scientific concepts, facts, and theories (Metin Peten, 2022).

One of the best methods to accomplish these aims is in science labs. Fundamental conceptual and procedural information and abilities in science are introduced to the class in laboratory setting (Bybee, 2000; NRC, 1996). Laboratory activities, according to Tobin (1990), are a mechanism for students to learn through comprehending scientific concepts and simultaneously engage in generating knowledge by practicing science.

Despite the importance of laboratory practices in science teaching, many studies demonstrate that teachers don't incorporate laboratory practices in science lessons due to lack of time, materials, and environment (Böyük, Demir & Koç, 2011; Güneş, Şener, Germi & Can, 2013; Kakayev, 2019). The fact that science teachers do not acquire laboratory competencies at the university where they graduate is one of the reasons why teachers cannot integrate laboratory activities into science lessons (Böyük et al., 2011). As a result, it is well known that science instructors feel unqualified to teach laboratory applications because they lack the required tools and knowledge (Çepni, Ayas, Johnson & Turgut, 1997; Çepni, Akdeniz & Ayas, 1994).

Their self-efficacy towards the use of scientific laboratories is one of the characteristics that will influence how well pre-service science teachers (PSTs) perform in laboratory activities that they would undertake in their future professional careers (Kızılkapan & Saylan-Kırmızıgül, 2021). Self-efficacy, in its simplest form, would be expressed as person's trust in his/her abilities. According to Bandura (1997), self-efficacy is the beliefs, perceptions and judgments that people have about their successful completion of the activities they are involved in. According to Zimmerman (1995), self-efficacy is an individual's personal assessment about his/her ability to do and accomplish a task. Studies reveal that the academic achievement of students taught by

teachers who have high self-efficacy beliefs is higher (Goddard, 2001; Ross, Hogaboam-Gray, & Gray, 2004). Addition to this, the self-efficacy beliefs of teachers who design student-centered learning environments and enable students to construct their own knowledge tend to be higher than the self-efficacy beliefs of those who adopt the traditional teacher-centered teaching approach (Nie, Tan, Liao, Lau, & Chua, 2013).

Teachers' self-efficacy for science laboratory use may be characterized as their confidence in their capacity to instruct effectively or efficiently in the use of science labs and to have an impact on the attitudes, abilities, and accomplishments of their students. According to the goals of the scientific curriculum, science teachers are expected to have the competence to plan a laboratory-based teaching process (Bektaş, Tüysüz, Kırbulut & Çetin-Dindar; 2011). Due to this, it is crucial for science teachers to be conscious of their own self-efficacy while planning science laboratory experiments for online or in-person learning environments. (Keskin Geçer, 2018).

Studies examining the self-efficacy of science teachers and PSTs toward laboratory utilization are found in the related literature. Arnado, Pene, Fuentes, and Astilla (2022) examined the laboratory self-efficacy of 71 STEM teachers. They revealed that the teachers, most of whom had 9 years of experience, were able to carry out science laboratory practice in spite of having limited facilities and resources. It was also concluded that STEM teachers felt more productive while planning their lessons in the laboratory and felt better if a suitable study place is existed in the laboratory. Ekici (2009), in his study investigating biology teachers' self-efficacy for laboratory use, observed that teachers had a moderate self-efficacy and that this differed in favor of female teachers. Çınar and Demirci (2015) compared science teachers and PSTs' self-efficacy towards laboratory use and they found that science teachers had high self-efficacy, PSTs had medium self-efficacy. The two groups' levels of self-efficacy varied significantly. Widiyawati and Sari (2019) revealed that the average laboratory self-efficacy of PSTs was medium. Kılıç, Keleş, and Uzun (2015) aimed to improve science teachers' self-efficacy towards laboratory use by applying 44 laboratory experiments in 5 day-long training. The study revealed the teachers had moderate self-efficacy before training, but after training they had high self-efficacy, and this difference was significant. In the study of Büyük, Demir, and Erol (2010) investigating science teachers' efficacy towards laboratory studies, it was concluded that teachers did not sufficiently recognize and use the equipment in laboratories, lacked expertise in doing maintenance and repairs of these equipment, and could not use the laboratory method sufficiently in lessons. Consequently, it could be concluded that science teachers have high or medium and PSTs have medium self-efficacy for laboratory use.

Recently, technology is an integral part of education. Therefore, it is inevitable to include technology in education and learning environments for

educators who undertake the task of educating a generation that interacts so much with technology. In terms of time, material and economy, utilizing technology in education would be quite advantageous (Çakır & Keleş, 2018). While learning environments combined with technology appeal to students' different senses, it ensures that knowledge is permanent by enabling students with auditory and visual intelligence and individual differences to learn in three dimensions and visualize (Şimşek, 2017).

Science courses are among the courses in which students struggle to understand concepts and therefore, student-centered and personalized learning environments are needed to enable students to learn in three dimensions and visualize in their minds (An & Reigeluth, 2012). Especially those courses such as science and mathematics are often described as boring and difficult to understand by students (Setiawan & Soeharto, 2020). In science courses, students encounter many abstract concepts. Abstract concepts can be more challenging to comprehend than concrete concepts. Therefore, it is not surprising that most students have misconceptions in science (Gülçiçek & Güneş, 2004).

It is thought that technology-supported applications will support the elimination of existing misconceptions by enabling students to concretize science concepts with their own experiences and will prevent misconceptions. With simulations, phenomena that can be encountered in daily life are brought to the learning environment, and the scientific concepts and processes are taught to students more effectively (Bozkurt, 2008). Abstract concepts are made concrete by supporting abstract concepts with simulations and enabling students to use at least one of the five sensory (Öner & Yaman, 2020). The use of simulations, especially in science laboratories, allows learners to have a laboratory process away from danger, to learn concepts interactively and progressively, and at the same time, it is economical in terms of time and material (Özer, Canbazoğlu Bilici & Karahan, 2015).

The related literature shows that technology-supported applications such as simulation and animation are effective in eliminating students' misconceptions by making abstract concepts such as light, sound, electricity, force and motion concrete (Erbaş & Demirer, 2015; Karamustafaoğlu, Aydın & Özmen, 2005; Taşlıdere, 2014). In addition, as a result of the combination of teaching materials with technology, visually enriched course materials attract students' attention and motivate them more (Güvercin, 2010; Jiau, Chen & Ssu, 2009). As a result of interviews with students, Şimşek (2017) found that students had a pleasant time in science lessons enriched with simulation and animation applications and were willing to actively involve in the lesson. Additionally, using technology-supported learning environments in science teaching increases students' academic achievement (Arıkan, 2003; Dağdalan, 2019; Derviş, 2009; Karamustafaoğlu, Aydın & Özmen, 2005; Olgun, 2006)

and attitudes towards the course (Aslan Efe, Oral, Efe & Öner Sünkür, 2011; Sakız, Özden, Aksu & Şimşek, 2014). It is seen that science teaching practices supported by simulation applications improve students' scientific process skills and are effective in involving students in processes such as determining and changing variables and collecting data during simulation interaction (Duygu, 2018; Özer et al., 2015). Therefore, laboratory practices enriched with technology integration contribute to the development of students as science literate individuals who can use scientific process skills, investigate and inquire into. In this context, it is very important to prepare technology-based science teaching activities (Widiyatmoko, 2018).

It is thought that teachers and PSTs who have the sufficient self-efficacy towards science laboratory use will have positive attitudes and self-efficacy towards laboratory practices even in the case of different limitations or in distance education processes (Kızkapan & Saylan-Kırmızıgül, 2021) and will be able to conduct their laboratory activities by using technology under any condition (Bakioğlu & Çevik, 2020). Therefore, teachers and PSTs need to be sufficiently acquainted with technological pedagogical content knowledge (PCK) in order to use innovative technology applications such as simulation, animation and augmented reality in science teaching and laboratory activities (Canbazoğlu Bilici & Baran, 2015). Knowledge of the curriculum and subject matter, how to teach it, how the field relates to other fields, the most recent advancements in the field, the fundamental concepts, tools, and structures of the field, and the integration of the content to be taught with technology are all characteristics of technological PCK (Turkish Education Association [TED], 2009).

However, Bakioğlu and Çevik (2020) found that the majority of the science teachers believed they could not conduct laboratory activities in online education in the time of the Covid-19 pandemic process, and therefore had concerns about this issue. Additionally, the researchers found that teachers who thought that they could carry out laboratory studies in distance education by showing experiment videos and did not include interactive technological applications such as simulation or animation. Bostan Sarioğlu, Altıntaş, and Şen (2020) found that science teachers believe that it is difficult to conduct lesson based on active learning in distance education and that making experiment in distance education is less successful than in-person. Although the use of technology has increased, integrating technology into learning environment is perceived as complicated by PSTs due to their lack of technological content knowledge (Berrett Murphy & Sullivan, 2012). In summary, it is seen that teachers are inadequate in designing science laboratory activities through innovative technology applications such as simulation, animation and augmented reality. However, studies about science teachers' self-efficacy of using information technologies in general show that teachers have moderate

or high self-efficacy beliefs (Avcı, 2014; Balçın & Ergün, 2018; Birhanlı & Gündüz, 2021; Çelik & Karamustafaoğlu, 2016). In their study conducted with science teachers, Sakin and Yıldırım (2019) revealed that teachers had a high technological PCK self-efficacy and that their self-efficacy differed according to their access to educational technologies, whether they received training or not, or whether they considered the training they received in undergraduate level sufficient. In this context, significant positive relationship between teachers' technological PCK self-efficacy and their attitudes towards using instructional technology was existed (Sakin & Yıldırım, 2019), frequency of using instructional technology (Karademir, 2015; Kırındı & Durmuş, 2019) and self-efficacy of designing materials (Bakaç & Özen, 2017).

Based on this context, in the case of constraints such as time, space, resources, inability of taking certain precautionary measures, or in situations where students' interaction is difficult, such as distance education, science teachers are supposed to have the competence to design science teaching and laboratory activities by utilizing technology-supported applications and to contribute to the development of students as science literate individuals by developing their scientific process skills through these activities. Therefore, it is believed that training teachers who appreciate the role of technological developments in education, integrate these developments into their lessons with different teaching methods and techniques, update themselves and have PCK will take part in a significant role in raising the merit of education. In this vein, it is believed that PSTs' self-efficacy towards the use of science laboratory and their self-efficacy towards technological PCK may be related and it is important to investigate this relationship. In related literature, despite the fact that there are studies investigating PSTs' self-efficacy towards use of science laboratory and technological PCK, according to authors' best knowledge no study which is directly investigating the relationship between these two self-efficacies was found. Therefore, the main goal of the study was to examine PSTs' self-efficacy for science laboratory use and technological PCK, and to investigate the relationship between these two self-efficacies. In addition, it will be investigated whether PSTs' self-efficacy of science laboratory use and self-efficacy of technological PCK differ in terms of gender, grade level, taking Laboratory Applications in Science Teaching and Information Technologies courses.

Method

Research Desing

In this study, correlational research design, one of the non-experimental quantitative research designs, was applied. The correlational research model is applied to study the relationship between one or more quantitative variables (Johnson and Christensen, 2012). In correlational relational research, "the

relationships between variables are examined without any intervention to influence them” and in such research, the degree to which two or more quantitative variables are related is expressed by a correlation coefficient (Fraenkel, Wallen & Hyun, 2012, p. 331).

Participants

The participants of the present research comprised 156 PSTs from 21 different state universities. The participants were either PSTs who are currently enrolled in science teaching undergraduate programs or who have recently graduated from School of Education. The data was gathered in the 2022-2023 academic year. The participants of the present research were chosen in accordance with the convenience sampling method (Christensen, Johnson, & Turner, 2015; Patton, 2002). This sampling is sampling that is easy to reach and conducted with volunteers who are willing to participate in the research (Fraenkel, Wallen & Hyun, 2012). Frequency (f) and percentage (%) of the participants in terms of gender, age and grade level are presented in the table below.

Table 1. *Demographic Information of the Participants*

Variable	Category	f	%	Variable	Category	f	%
Gender	Woman	132	84,6	Grade	Sophomore	11	7,1
	Man	21	15,4		Junior	67	42,9
Age	18-24	144	92,3		Senior	64	41,0
	25-34	12	7,7		Graduate	14	9,0

Data Collection

Two data collection tools were used to collect data. The Science Laboratory Use Self-Efficacy Scale was used to determine the self-efficacy levels of PSTs towards science laboratory use, and the TPACK Self-Efficacy Scale of Pre-Service Science Teachers on Material Development was used to determine the self-efficacy of PSTs towards technological PCK.

Science Laboratory Use Self-Efficacy Scale (SLUSE)

Science Laboratory Use Self-Efficacy Scale was developed by Kızıkan and Saylan-Kırmızıgül (2021), consists of 27 items and four sub-scales. The first sub-scale was named as “Self-efficacy to use physical environment and equipment in science laboratory”, the second as “Self-efficacy to apply scientific process skills”, the third as “Self-efficacy to work independently in science laboratory” and the fourth as “Self-efficacy to manage crisis in science laboratory”. Exploratory and confirmatory factor analysis were conducted for the construct validity of the scale. Reliability coefficient of the scale was

0.85. The reliability coefficients for sub-scale were 0.78, 0.73, 0.68 and 0.59, respectively.

TPACK Self-Efficacy Scale of Pre-service Science Teachers on Material Development (TPACK Self-Efficacy)

TPACK Self-Efficacy Scale of Pre-service Science Teachers on Material Development was developed by Balçın and Ergün (2016), consists of 40 items and eight sub-scale. The name of the sub-scales are TPCK, TK, CK on basic and sub-specialties of science, PK, CK, PCK, TCK, TPK. Exploratory and confirmatory factor analysis were conducted for the construct validity of the scale. Cronbach’s alpha reliability coefficient for the whole scale was found to be 0.93. The reliability coefficients of the sub-scale were 0.88, 0.80, 0.76, 0.85, 0.80, 0.82, 0.69 and 0.75.

Data Analysis

Descriptive and statistical analysis were utilized in SPSS software. Before starting the analysis, the data were checked in terms of normal distribution. Since there was no normal distribution, nonparametric methods were preferred in the data analysis process.

Mean, standard deviation, frequency and percentage of the data were calculated to investigate the PSTs’ SLUSE and TPACK self-efficacy. Spearman correlation test was utilized to investigate the relationship between PSTs’ SLUSE and TPACK self-efficacy. Mann Whitney U test was applied to determine whether PSTs’ SLUSE and TPACK self-efficacy differed in terms of gender and whether PSTs’ SLUSE differed in terms of whether they took Laboratory Applications in Science Teaching course or not or whether their TPACK self-efficacy differed in terms of whether they took Information Technologies course or not. Kruskal-Wallis analysis was applied to determine whether PSTs’ SLUSE and TPACK self-efficacy differed in terms of grade level or university type.

Results

Results Related to the Sub-Problem 1

The data related to the sub-problem “What are the self-efficacy levels of PSTs towards science laboratory use?” were analyzed with descriptive statistics. The descriptive statistics of the scores of PSTs on the Science Laboratory Use Self-Efficacy scale are stated below.

Table 2. *Descriptive Analysis Findings Related to the Scores of Pre-service Science Teachers’ SLUSE*

Scale	$\bar{X}$	Min.	Max.	sd
Science Laboratory Use Self-Efficacy	106.02	65	134	11.91

The table presented that the lowest score obtained by PSTs on the SLUSE is 65 and the maximum score is 134. The average score gained from the scale is 106.02. The ratio of this score to the number of items was found to be 3.92. This average corresponds to the statement “mostly agree” and it is seen that pre-service teachers have a “high” self-efficacy towards the use of science laboratory.

Results Related to the Sub-Problem 2

The data related to “What are the self-efficacy levels of PSTs towards technological pedagogical content knowledge?” were examined with descriptive statistics. Descriptive analysis findings related to the scores of PSTs’ TPACK Self-Efficacy Scale on Material Development are presented in the table below.

Table 3. *Descriptive Analysis Findings Related to the Scores of Pre-service Science Teachers’ TPACK Self-Efficacy Scale for Material Development*

Scale	$\bar{X}$	Min.	Max.	sd
TPACK Self-Efficacy Scale on Material Development	160.25	108	200	16.65

The table presented that the lowest score obtained by PSTs on the TPACK self-efficacy scale is 108 and the maximum score is 200. The average score gained from the scale is 160.25. The ratio of this score to the number of items was found to be 4.00. This average corresponds to the statement “mostly agree” and, it is concluded that pre-service teachers have “high” TPACK self-efficacy on material development.

Results Related to the Sub-Problem 3

Spearman Correlation analysis was applied to analyze the data related to the sub-problem “Is there a relationship between PSTs’ SLUSE and TPACK self-efficacy?”. The findings related to the relationship between two variables are presented in the table below.

Table 4. *The Relationship Between PSTs’ SLUSE and TPACK Self-efficacy*

	Spearman’ rho correlation coefficient (r)	p
SLUSE and TPACK self-efficacy	.685**	p<0.001

The findings showed that the correlation coefficient between PSTs’ SLUSE and TPACK self-efficacy is rS: 0.685. Accordingly, it was concluded that positive and moderate correlation between PSTs’ self-efficacy levels for science laboratory use and their self-efficacy levels for technological PCK was available (rS: 0.685, p<0.01).

Results Related to the Sub-Problem 4

The data related to the sub-problem “Do pre-service science teachers’ SLUSE and TPACK self-efficacy differ in terms of gender?” were analyzed by Mann Whitney analysis. The analysis result is stated below.

Table 5. Analysis of Pre-Service Science Teachers’ SLUSE and TPACK Self-efficacy in Terms of Gender

		N	Mean Rank	Mann Whitney U Testi	
				Mann Whitney U	p
SLUSE	Female	132	77.36	1433,500	.459
	Male	24	84.77		
TPACK Self-efficacy	Female	132	77.30	1425.500	.436
	Male	24	85.10		

The results of the analysis show that PSTs’ SLUSE and TPACK self-efficacy do not differ statistically in terms of gender.

Results Related to the Sub-Problem 5

The data related to the sub-problem “Do pre-service science teachers’ SLUSE and TPACK self-efficacy differ in terms of grade level?” were analyzed by Kruskal Wallis analysis. The analysis result is stated below.

Table 6. Analysis of Pre-Service Science Teachers’ SLUSE and TPACK Self-efficacy in Terms of Grade Level

	Grade Level	N	Chi-Square	p
SLUSE	2	11	12.248	.007*
	3	67		
	4	64		
	Graduate	14		
	Grade Level	N	Chi-Square	p
TPACK Self-efficacy	2	11	20.712	.000*
	3	67		
	4	64		
	Graduate	14		

The findings showed that PSTs’ self-efficacy towards SLUSE and TPACK differ significantly as the grade level changes. The rank averages of 2nd, 3rd, 4th grade and newly graduated pre-service teachers’ self-efficacy for science laboratory use are 44.05, 71.93, 87.95 and 93.82, respectively. The analyses show that 2nd and 3rd grade PSTs’ self-efficacy towards the use of science laboratories differ significantly from 4th grade and newly graduated PSTs’ self-efficacy towards the use of science laboratories.

The mean ranks of 2nd, 3rd, 4th and newly graduated pre-service teachers' self-efficacy for technological PCK are 51.86, 64.07, 94.11 and 97.14, respectively. The analysis shows that 2nd and 3rd grade PSTs' self-efficacy levels towards technological PCK differ significantly from 4th grade and newly graduated PSTs' self-efficacy towards technological PCK.

Results Related to the Sub-Problem 6

Kruskal Wallis analysis was applied to examine the data related to “Do pre-service science teachers' SLUSE and TPACK self-efficacy differ in terms of university type?”. The analysis result is stated below.

Table 7. *Analysis of Pre-Service Science Teachers' SLUSE and TPACK Self-efficacy in Terms of University Type*

	University type	N	Chi-Square	p
SLUSE	21 different universities	156	29.590	.077
TPACK self-efficacy	21 different universities	156	27.455	.123

The findings stated that the self-efficacy of PSTs towards science laboratory use and their self-efficacy towards technological PCK do not differ significantly as the type of university changes.

Results Related to the Sub-Problem 7

The data related to the sub-problem “Do pre-service science teachers' SLUSE differ in terms of whether they take Laboratory Applications in Science Teaching course or not?” were analyzed with Mann Whitney analysis. The analysis result is stated below.

Table 8. *Analysis of Pre-Service Science Teachers' SLUSE in Terms of Laboratory Applications in Science Teaching Course*

	Laboratory Applications in Science Teaching	N	Mean Rank	Mann Whitney U Test	
				Mann Whitney U	p
SLUSE	Took the course	147	80.54	361.500	.022*
	Did not take the course	9	45.17		

The related findings stated that whether or not the PSTs take the Laboratory Applications in Science Teaching course in the undergraduate program statistically significantly differentiates their SLUSE in favor of the PSTs who take the course.

Results Related to the Sub-Problem 8

The data related to “Do pre-service science teachers’ TPACK self-efficacy differ in terms of whether they take Information Technologies course or not?” were analyzed with Mann Whitney analysis. The analysis result is stated below.

Table 9. Analysis of Pre-Service Science Teachers’ TPACK Self-efficacy in terms of Information Technologies Course

	Information Technologies	N	Mean Rank	Mann Whitney U Testi	
				Mann Whitney U	p
TPACK Self-efficacy	Took the course	134	79.84	1294.500	.360
	Did not take the course	22	70.34		

The related findings stated that whether or not the PSTs take the “Information Technologies” course in the undergraduate program does not statistically significantly differentiate their self-efficacy towards technological PCK.

Conclusion and Recommendations

In this study, PSTs’ self-efficacy for science laboratory use and self-efficacy for technological PCK were investigated and the relationship between these two self-efficacies was examined. In addition, it was investigated whether PSTs’ self-efficacy for science laboratory use and self-efficacy for technological PCK on material development differ according to different variables.

According to the results, PSTs from 21 different universities who participated in the study had high self-efficacy towards the use of science laboratories. The self-efficacy of PSTs towards the use of science laboratories did not demonstrate a significant difference in terms of their gender and university. This finding is consistent with the findings of the study conducted by Çınar and Demirci (2015) with both science teachers and pre-service teachers. However, Arnado, Pene, Fuentes, and Astilla (2022) reported that STEM teachers’ and Ekici (2009) reported that biology teachers’ self-efficacy towards science laboratory use differed significantly in favor of female teachers. Self-efficacy of PSTs towards science laboratory use differed significantly in terms of grade level. As the grade level increases, PSTs’ self-efficacy towards the use of science laboratories increases and this increase is differentiated in favor of 4th grade and newly graduated PSTs. Ince Aka (2016) reported that PSTs have high self-efficacy for the use of science laboratories, their self-efficacy increase as the grade level increases, and their self-efficacy differ significantly against first-year PSTs. These findings are resembling to the findings of the current study. In the current research, it was also observed that PSTs’ self-efficacy towards the use of science laboratories differed significantly in favor

of PSTs who took the Science Teaching Laboratory Practices course. Similarly, Kılıç, Keleş, and Uzun (2015) reported that teachers' self-efficacy increased from medium to high level and this difference was statistically significant in their study in which they aimed to improve science teachers' self-efficacy towards laboratory use by applying 44 laboratory experiments. Participation of teachers and PSTs in laboratory activities affects their self-efficacy towards science laboratory use.

The results of the research also revealed that PSTs have high self-efficacy for technological PCK. Many studies conducted with similar samples in the literature indicate that PSTs have high self-efficacy for technological PCK (Bakaç & Özen, 2017; Birhanlı & Gündüz, 2021; Sakin & Yıldırım, 2019; Thohir, Jumadi & Warsono, 2022; Wright & Akgunduz, 2018). The PSTs' self-efficacy towards technological PCK does not reveal a significant difference in terms of their gender and university. This finding obtained related to gender resembled to other studies in the literature (Birhanlı & Gündüz, 2021; Karademir, 2015; Sakin & Yıldırım, 2019). Self-efficacy of PSTs towards technological PCK differs significantly in terms of grade level. As the grade level increases, PSTs' self-efficacy towards technological PCK increases and this increase is in favor of 4th grade and newly graduated PSTs. In the study conducted with pre-service science and mathematics teachers, Bwalya and Rutegwa (2023) reported that PSTs' self-efficacy towards technological PCK differed significantly according to grade level, but this difference between 3rd and 4th grades was in favor of 3rd grades. The results of the research also revealed that PSTs' self-efficacy towards technological PCK does not differ in terms of taking Information Technologies course. Jang and Tsai (2013) stated that one of the crucial factors influencing PSTs' technological PCK is teaching experience. Similarly, Wang and Zhao (2021) showed that institutional support has strong and positive effects on the improvement of pre-service teachers' technological PCK and stated that pre-service teachers can improve their self-efficacy towards technological PCK by applying and utilizing the technologies they learn in teaching. In addition, Wright and Akgunduz (2018) stated that PSTs who are producers of Web 2.0 applications have statistically significantly higher self-efficacy for technological PCK than PSTs who are only consumers. Making instructional designs by utilizing Web 2.0 applications as a producer rather than just knowing and using them positively affects self-efficacy towards technological PCK.

The results of the study also show that there is a positive and moderate correlation between PSTs' self-efficacy of science laboratory use and their self-efficacy of technological PCK. The high self-efficacy of PSTs and the moderate positive correlation between these self-efficacies strengthen the prediction that PSTs would be able to design science teaching and laboratory activities by utilizing technology-supported applications in the future. This study is limited to the data obtained from 156 PSTs from 21 different universities. Therefore,

it is recommended that similar studies be conducted with larger samples and especially with science teachers.

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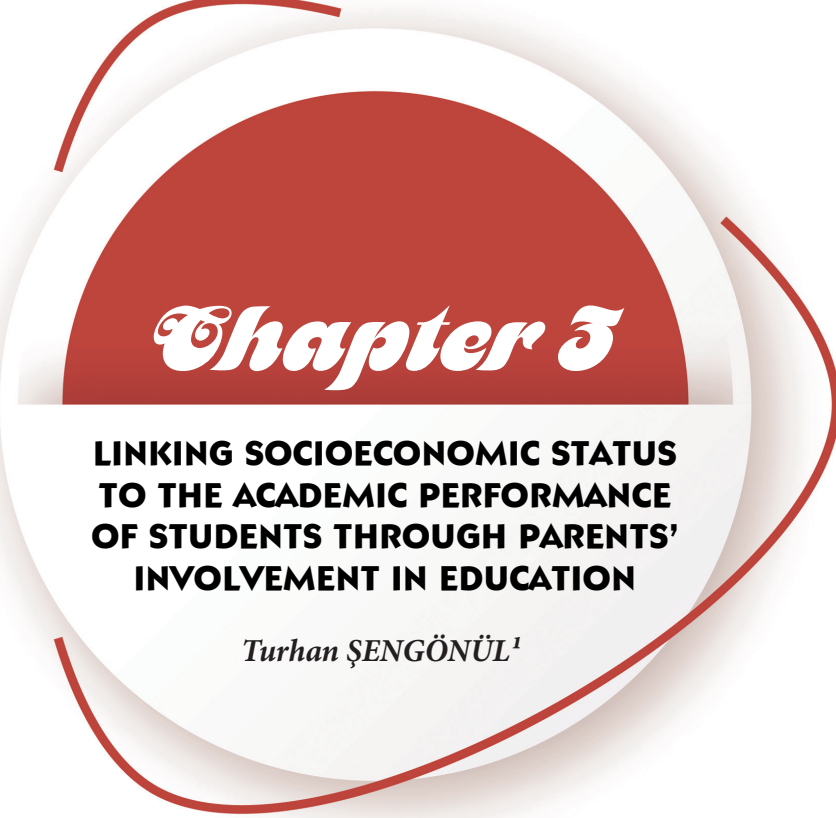
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Chapter 3

LINKING SOCIOECONOMIC STATUS TO THE ACADEMIC PERFORMANCE OF STUDENTS THROUGH PARENTS' INVOLVEMENT IN EDUCATION

Turhan ŞENGÖNÜL¹

¹ Doç. Dr. Ege Üniversitesi, Eğitim Fakültesi, Temel Eğitim Bölümü, Sınıf Eğitimi Anabilim Dalı

Introduction

The present research addressed the impacts of socioeconomic status (SES) on students' academic performance and investigated whether parental involvement in education mediated these impacts. Results revealed that the factor with the strongest direct association with students' test points was the mother's occupation, which was followed by family income. Also, the education level of mothers, but not fathers, predicted students' academic performance. Parents' involvement in their children's education mediated the effects of both family income and mother's education on students' academic performance. Paths between socioeconomic status parental involvement and students' academic performance showed that parents mobilized, used and spent their economic, social and human capital for education and academic success of their children. Mothers and fathers played specific roles in education and academic performance of their children

Parents' hopes and expectations for their children's success in life were often examined through children's education and academic performance in school. It was asserted that performing well at school and doing well academically was associated with doing well economically in later life (Butler, Beach, & Winfree, 2008). It was also emphasized that for many children, their chances of academic success were reduced as a consequence of poverty (Duncan & Brooks-Gunn, 2000), and the academic performance of children was strongly predicted by the socioeconomic status of families (Sirin, 2005). It was suggested that the educational and academic achievement of children was a key mechanism for preventing the transfer of poverty from generation to generation in societies and families (Orfield, Losen, Wald, & Swanson, 2004). That being said, researchers and practitioners needed to have more knowledge about and become more familiar with the relationship processes that existed between the socioeconomic status of families and children's academic outcomes in order to effectively intervene in and prevent the transfer of poverty from generation to generation in societies and families.

Poverty rates increased and spread in societies and families. Compared to wealthier sections of the society, it was observed that there were fewer individuals in poor families who had high school diplomas or university degrees, or received postgraduate education (U.S. Census, 2009). Studies postulated that many poor parents cared about their children's education, had high expectations for educational success of their children, and engaged in a variety of activities to increase and enhance their academic performance (Chrispeels & Rivero, 2001; Quiocho & Daoud, 2006). Students from families in lower socioeconomic status demonstrated lower academic performance compared to their peers from families in higher socioeconomic status. It was stated that academic success indicators such as grades and performance on standardized tests were generally lower among students from poor families

(Kao & Thompson, 2003; Portes & Rumbaut, 2002). Furthermore, students from poor families had comparatively higher dropout rates (Driscoll, 1999; Laird, DeBell, Kienzl, & Chapman, 2007; U.S. Census, 2009). It was stressed that children from families in poorer and lower socioeconomic status were likely to encounter significant risks and barriers in terms of educational success and advancement.

It was suggested that the impacts of family socioeconomic status on children's educational outcomes were predominantly mediated by closer factors within the context of family, school, and neighborhood (Bradley & Corwyn, 2002). These enabled parents to provide potential points and take initiatives to intervene in and prevent the transfer of disadvantages from generation to generation. By involving and engaging in their children's education, parents were often able to undertake interventions as a means to enhance and improve their children's academic outcomes. The current research addressed the influence of socioeconomic status on students' academic performance and examined to what extent parents' interest in their children's education mediated the relationship between socioeconomic status and academic performance of students.

Socioeconomic Status and Educational Outcomes of Students

Socioeconomic status was described as a concept representing a family's possibilities of accessing to and benefiting from social and economic resources. Researchers and theorists continued to their debates on how socioeconomic status should be conceptualized and how a variety of determinants could be used to define and conceptualize it. Socioeconomic status was conceptualized in different and diverse ways, varying from a multi-indicator structure to a unique set of elements, and was operationalized and implemented experimentally (Bollen, Glanville, & Stecklov, 2001). Studies most frequently measured and assessed socioeconomic status making use of three key variables - namely family income, education level of parents, and occupations of parents (Bradley & Corwyn, 2002). While family income was an indicator of the financial resources available and accessible in the family, parental education levels and occupations demonstrated the intellectual and cognitive resources as well as social status or human and social capital of the parents (Conger & Donnellan, 2007). A meta-analysis of studies investigated the association between socioeconomic status and students' educational consequences and demonstrated that various elements of socioeconomic status, such as family income, education of parents, and occupation of parents, had different impacts on students' educational consequences (Şirin, 2005). Moreover, as socioeconomic status elements were often correlated, the fact that only one measure of socioeconomic status was included in the analysis might overestimate the impact of this particular element (Şirin, 2005). Thereby, it was emphasized that it was crucial to simultaneously consider and

bear in mind the unique impacts of multiple elements of socioeconomic status when examining the association between socioeconomic status and students' educational performance.

Related studies revealed that socioeconomic status significantly predicted students' academic outcomes, such as test points (Morales & Saenz, 2007), grade point average (Portes & Rumbaut, 2001), and dropout rates (Stearns, Moller, Blau, & Potochnick, 2007). These studies investigated the impact of a single socioeconomic status factor by adding either a combined element of multiple indications or a single measure of socioeconomic status. There were just a few studies that examined the association between multiple elements of socioeconomic status and students' educational consequences. Only one of these studies investigated the multiple elements of socioeconomic status with regard to students' academic performance on standardized tests employing a national sample of students in the first through eighth grades and discovered that parental education most strongly predicted reading and math achievement of students compared to family income (Roscigno, 2000). Studies employing data from the 1990 United States Census investigated the factors related to school dropout among students (Landale, Oropesa, & Llanes, 1998) and immigrant adolescents (Feliciano, 2001). These studies established that education of parents was the socioeconomic status element that had the strongest protective impact on school dropout. Another study that included measures of family income and parental education (Driscoll, 1999) and examined the dropout rates of Hispanic students discovered that family income was the sole significant predictor of student dropout.

The literature postulated that different elements of socioeconomic status had unique associations with students' educational consequences. When family income and parental education variables were included in the analysis of socioeconomic status elements, the education variable of parents had a stronger effect on students' educational results (Althschul, 2012). It was discussed which socioeconomic status elements had the strongest effects, especially in terms of their effects on students' educational success, such as performance on standardized tests. The current study aimed to simultaneously investigate the impacts of main indicators of socioeconomic status, including family income, parental education and parental occupation, on the academic achievement of students and also to contribute to the existing literature in this field.

The present study examined the impacts of mothers' and fathers' education and occupation separately. Parents and adolescents reported that mothers and fathers assumed different roles within socializing, educating, and rearing processes (Parra-Cordona, Cordova, Holtrop, Villarruel, & Wieling, 2008). Furthermore, mothers' and fathers' involvement seemed to affect students' academic outcomes through a variety of processes (Plunkett

et al., 2008). Since education and occupation served as indicators of parents' human and social capital, such resources they had access to were likely to have a significant impact on parents' involvement and engagement in their children's education. Considering the fact that their education and occupation could provide human and social capital for parents, they were able to involve and engage in the education of their children by mobilizing, using and spending their human and social capital. Thanks to their human and social capital, parents were able to provide their children with resources, materials, services, activities and experiences that could promote and contribute to their educational development and academic performance. Fathers were more engaged in discussing academic issues with adolescents than mothers, and fathers' education levels were more likely to affect discussing school-related issues at home compared to mothers' education levels (Parra-Cordona et al., 2008). This research not only dealt with the opportunities for both mothers and fathers to reach and benefit from human and social capital independently for the educational development and academic performance of children but also examined the opportunities that were provided by family income, which could be generally measured at the family level and shared within families, and was largely transferable and conveyable, for the family as a whole to access financial resources.

Parental Involvement and Educational Performance of Students

Parents' involvement in their children's education was defined as parents' allocating, using, and spending resources for their children's education and academic achievement. Parental involvement was conceptualized within the context of parental behavior and their personal support for the education of their children, and parents' providing their children with materials and activities that cognitively stimulate and enhance their development (Grolnick & Slowiaczek, 1994). Other efforts to conceptualize parental interest in education stressed both home and school-based interest of parents in education of their children (Pomerantz, Moorman, & Litwack, 2007). In the current research, parents' interest in children's education was described and measured within the context of (a) financial and personal resources of parents to ensure activities that stimulate and advance their children cognitively and intellectually, such as providing extracurricular instruction opportunities and educational resources and engaging children in enriching educational activities, and (b) parents' allocating and spending time on school-related activities at home and at school, such as talking about and discussing school issues with children, providing help with homework, and participating in school organizations.

Prior research identified relationships of parental interest in education with positive educational consequences of students. Parents' talking about and discussing school issues with their children were linked to higher test

points and grades of adolescents (Altschul, 2011). Likewise, parents' providing educational resources, enriching activities and extracurricular instruction opportunities were linked to higher test points of adolescents (Altschul, 2011). Educational and academic support provided by parents as well as their ability to help their children with academic issues, such as homework, appeared to be related to the academic motivation of adolescents (Plunkett, Henry, Houlberg, Sands, & Abarca-Mortensen, 2008). Another study explored adolescents' perceptions of parental interest in education and discovered that students who felt that their parents maintained high educational expectations for them showed a tendency to achieve higher grade point averages. Nonetheless, students' perceptions of parents' talking about and discussing school issues with their children, monitoring school, helping with homework did not seem to be associated with their GPAs and academic aspirations (Carranza et al., 2009). It was asserted that parental involvement in children's education might be a promising link between family socioeconomic status and academic outcomes of students.

Theoretical Framework Linking Socioeconomic Status to Academic Outcomes of Students through Socializing, Educating and Rearing Children

Various literature associating family socioeconomic status and educational outcomes of children and adolescents indicated that socioeconomic advantages and disadvantages were conveyed to children and adolescents through socialization, education, and rearing processes (Bradley & Corwyn, 2002). The family stress model suggested that economic difficulties caused stress and tension in parents, and these might lead to parental conflicts and depression in families. The family stress model pointed out that the stress, tension, and depression caused by economic difficulties might reduce the positive forms of parenting behaviors and practices, such as child socialization, education and rearing, as well as the psychological well-being of children. These family stress processes might impact involvement in education that necessitated time and attention of parents, such as talking about and discussing school issues with children and adolescents, and engaging in school activities and organizations. The family stress model also suggested that the mechanisms for the pathways and transition between socioeconomic status and educational outcomes of children and adolescents were most strongly associated with family income rather than with education levels or occupations of parents.

A second explanation for the impacts of socioeconomic status on the educational outcomes of children and adolescents was proposed by the family investment theory. This theory postulated that as a family's socioeconomic resources increased, so did parents' ability to mobilize, use, and spend their resources - both monetary capital and human and social capital - towards improving and enhancing the educational and academic outcomes of children and adolescents. This theory highlighted parents' choices and preferences

in deciding how much of existing and available resources to designate for various purposes in the family (Mayer, 1997). Although they depended on individual and cultural preferences, it was expressed that these choices could be limited and determined by the resources that existed and were available in the family. Family investment theory underlined the significance of parents' investing both time and money in education in order to increase and enhance the economic, social and human capital as well as cognitive, intellectual and academic development of their children and adolescents. Family investment theory combined family income with parental education and occupation in order to explain the impacts of parental investment on the educational and academic outcomes of children and adolescents. Family income was accepted as an indicator of existing and available economic resources; whereas, parent education and occupation were regarded as indicators of human and social capital of parents and as variables that can affect parental preferences. Parental education and occupation, as well as family income, affected the way parents spent both time and money to improve and enhance the education and academic performance of their children and adolescents. It was asserted that parents who themselves achieved higher levels of education were able to provide activities that could be more valuable and that could improve and stimulate their children cognitively and intellectually compared to parents with more limited formal education. Nonetheless, family income might either enhance or restrict the ability of parents to provide educational activities and opportunities that require spending money, such as private tuition, extracurricular instruction or university prep courses (Altschul, 2012).

It was asserted that the family stress model and family investment theory explained the association between socioeconomic status and parenting processes, such as socialization, education, and rearing, and the educational outcomes of children and adolescents, and that these two models were not mutually exclusive. It was highlighted that family stress processes operated simultaneously with processes where parents allocated time, spent money and invested in the education of children and adolescents. The family stress model and the family investment theory attempted to explain the impact of socioeconomic status on socialization, education, and rearing processes as well as academic outcomes of children and adolescents. Various studies evaluated the relationship of both the family stress model and the family investment theory with cognitive and behavioral consequences of children and adolescents. While researchers asserted that parental stress and tension were often associated with children's behavioral outcomes, they discovered that the investment, time, and money that parents designated to their children's education were often related to cognitive development of children (Gershoff, Raver, Aber, & Lennon, 2007; Yueng, Linver, & Brooks-Gunn, 2002). In view of the studies using different nationally representative datasets, it was argued that the findings of studies

performed on children at different stages of development, from infants to primary school age, were strong and sound. It was suggested that since early behavioral problems most likely affected the academic performance of students by the time adolescents entered high school (Hill et al., 2004), both family stress and tension stemming from economic difficulties and parental investments associated with family income, parental education and parental occupation could play a crucial role in educational outcomes of children. It was deemed important to examine and determine through research whether the investments made by parents in their children's education had a dominant influence on the cognitive outcomes and academic performance of children and adolescents.

Current Study

The current research utilized nationally representative data in order to examine the impacts of socioeconomic status on educational and academic performance of students. Family income, parental education, and parental occupation as multiple elements of socioeconomic status were examined simultaneously. The prominent roles of mothers and fathers in the socialization, education and upbringing processes as well as the impacts of parental education and parental occupation were also investigated separately. The research tested the hypothesis that certain elements of socioeconomic status had unique impacts on students' academic performance. Furthermore, the research built on a new study that examined socialization, education, and rearing processes as a link between socioeconomic status and cognitive and behavioral outcomes of children. It was asserted that parental involvement in education potentially mediated the impacts of socioeconomic status on educational and academic performance of students. It was underlined that interest of parents in their children's education played a crucial role in transferring and conveying socioeconomic advantage to the cognitive and behavioral outcomes of the students. The current study tested two hypotheses about the role of parental interest in education in transferring and conveying socioeconomic advantage to students' cognitive and behavioral consequences. The first hypothesis suggested that parents' interest in their children's education mediated the association between socioeconomic status and cognitive and behavioral consequences of children. The second hypothesis asserted that processes associated with the parental investment theory played a more significant role in students' academic performance compared to processes associated with the family stress model.

METHOD

The current study used data drawn from the National Educational Longitudinal Survey of 1988. The National Educational Longitudinal Survey, (NELS), a large, nationally representative, longitudinal dataset, was collected by the National Center for Education Statistics to explore the educational processes and outcomes of secondary school students (Curtin, Ingels, Wu, &

Heuer, 2002). The mean age of 1609 eighth grade students who participated in the longitudinal survey was approximately 14.3, with a standard deviation of 62. Female students made up 51.4 % of the sample.

Measures

Variables for socioeconomic status, controls, and parental involvement were collected from the student and parent questionnaires and used to predict students' academic performance. Students' academic achievement scores were obtained by administering four standardized tests in reading, mathematics, science and history. Scores obtained from these four tests were then combined into a single score.

Socioeconomic Status

Five elements of socioeconomic status, namely family income, mother's education, father's education, mother's occupation, and father's occupation were included in the research. Parents reported their income sequences by selecting one of 15 income categories ranging from none, less than \$1,000 to \$200,000 or more. Mothers and fathers reported the highest levels of education they had. The occupations of the mothers and fathers were obtained from the responses given by the parents about their own or spouse's occupations. Occupations were specified according to Duncan socioeconomic index (SEI) values for analysis (Ingels, Scott, Lindmark, Frankel, & Myers, 1992). Among fathers and mothers, the median occupation was defined as a butcher, collector or assembler, machine operator, welder, taxi, bus or truck driver.

Parents' Involvement in Education

Parental involvement was assessed by measures such as talking about and discussing school-related issues with children, helping with homework, participating in school organizations, providing educational resources at home, extracurricular instruction and enriching activities. These parental involvement variables or measures were also referred to in the educational literature. They were found to be compatible with key considerations of parental involvement and were developed and used for the National Educational Longitudinal Survey (NELS). When multiple indicators of parental involvement existed, the indicators were examined for internal reliability utilizing Cronbach's alpha and scales were constructed when internal reliability was appropriate. When multiple indicators were not causally related to the construct, the indicators were collected to develop an indicator rather than a scale (Bollen, 1989). Single items were used when multiple indicators were not available.

Talking about and Discussing School Related Issues with Children

Parents reported how often they talked about and discussed school-related issues, such as school experiences, plans for high school, and plans for post-secondary education with their children. The parent survey included three questions. Responses to each question were provided using a 4-point scale: never (0), rarely (1), sometimes-occasionally (2), and always (3). Three items associated with school experiences, plans for high school, and plans for post-secondary education were averaged to devise a scale. On average, the mean of the scale showed that parents talked about and discussed school-related matters with their children sometimes-occasionally and constantly ($M = 2.32$, $SD = .72$). The scale had a Cronbach's alpha value of .825.

Parental Help with Homework

Parents reported how often they helped their children with homework. They responded and expressed their preferences using a 4-point scale by stating that they had helped their children with homework very little or never (1), once or twice a month (2), once or twice a week (3), and almost every day (4). On average, parents helped their children with homework once or twice a month ($M = 2.01$, $SD = 1$).

Involvement in School Organizations

A 0 to 5 index of parental involvement in school organizations was devised by combining five types of parent-reported involvement, which included attending school meetings or events, volunteering at school, and being a member of a parent-teacher organization. On average, parents were engaged in some form of involvement in their child's school. Since few parents reported more than three types of involvement, these three types were coded at the top to reduce skewness ($M = 0.85$, $SD = 1.06$).

Educational Resources at Home

Students reported educational resources at home. The variable was calculated as a count of 10 specific items available at the student's home that could be helpful in school-related activities: It included items such as a separate place to study, daily newspapers, magazines, encyclopedias, atlases, dictionaries, typewriters, computers, more than 50 books, and a pocket-size calculator. For educational resources, the variable was calculated as a number of 10 distinct items available at students' homes that could be beneficial in school-based activities ($M = 5.94$, $SD = 2.23$).

Determining Extracurricular Instruction Resources

Parents reported whether their eighth graders attended courses outside of regular school in areas of interest such as art, dance and computer skills. The number of different types of instruction provided to students outside of

school was calculated. The count variable at the top was coded at two to reduce skewness ($M = 0.60$, $SD = 0.76$).

Involvement in Enriching Activities

Parents were inquired whether they and their children had attended enriching activities such as musical performances, visiting museums, borrowing books from libraries. An index of the number of enriching activities in which both parents and children were involved and engaged demonstrated that, on average, parents and children participated in fewer than two of the same enrichment activities ($M = 1.67$, $SD = 1.70$).

Table 1 *Correlations of socioeconomic status, parent interest, and test points of 10th grade students*

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. Education of mothers	-											
2. Education of fathers	.434	-										
3. Occupations of mothers	.523	.291	-									
4. Occupations of fathers	.228	.616	.271	-								
5. Income of family	.272	.441	.356	.408	-							
6. Discussing school issues	.174	.223	.177	.161	.220	-						
7. Providing enriching activities	.289	.259	.306	.197	.309	.308	-					
8. Involvement in school organizations	.180	.101	.134	* .085	.140	.209	.282	-				
9. Help with homework	.168	.218	.210	.117	.200	.321	.202	.141	-			
10. Educational resources	.327	.321	.318	.268	.405	.258	.297	.148	.158	-		
11. Extracurricular instruction	.306	.144	.264	* .074	.208	.136	.290	.268	.104	.264	-	
12. 10th grade test points	.260	.261	.311	.199	.274	.173	.249	.094	-.013	.282	.227	.082

*All correlations are significant at $p \leq .001$, * indicated significant at $p \leq .01$. (Altschul, 2012, p. 19)*

Analyses

Table 1 displays correlations between study variables. The two-path model was used to (1) determine the association between multiple socioeconomic status factors and educational and academic performance of students, and (2) assess to what extent parents' interest in their children's education mediated this association between multiple socioeconomic status factors and educational and academic performance of students. Path models explained the relationships between predictors and provided the means to evaluate indirect effects through mediating factors. The indirect impacts of socioeconomic status indicators on students' test points were predicted by simultaneously evaluating multiple involvement practices undertaken by parents (Preacher & Hayes, 2008).

RESULTS

Impacts of Socioeconomic Status on Test Points of Students

The first model evaluated to what extent socioeconomic status variables predicted 10th grade students' test scores and explained 14 % of the difference in 10th grade students' test points (Altschul, 2012, 20). The results revealed that 3 of the 5 socioeconomic status factors, namely mother's occupation, family income, and mother's education, were correlated with the test scores of their students. The three main predictors of socioeconomic status served as significant direct predictors of the test points of students. They were listed in order of magnitude with standardized regression coefficients of $\beta = .201$ for mothers' occupation, $\beta = .130$ for family income, and $\beta = .088$ for mothers' education. Fathers' education and occupation were not significantly associated with their students' test scores despite the fact that both characteristics of fathers had significant indirect associations through income, in terms of education ($\beta = .062$) and occupation ($\beta = .093$). Mothers' occupation significantly predicted students' test points above and beyond its indirect impact through family income ($\beta = .074$). Even though mothers' education was not associated with family income, it significantly predicted students' test scores (Altschul, 2012, 20). It was confirmed that education and occupation of parents, as indicators of parents' human and social capital, had an impact beyond the financial resources of the family. Besides, these findings underlined the explicit impacts of mothers and fathers' education and occupation on students' test scores.

Table 2 *Path coefficients among socioeconomic status, control and parental interest variables in Model 2*

Regression path	B	SE	β	p
10 th grade test points (R ² =.20) ON				
Discussing school issues	.1060	.422	.096	**
Providing enriching activities	.382	.185	.091	*
Involvement in school organizations	-.159	.256	-.023	
Parental help with homework	-1.252	.231	-.174	***
Providing educational resources in the home	.371	.097	.115	***
Providing extracurricular instruction	1.032	.425	.110	**
Education of mothers	.063	.106	.026	
Education of fathers	.218	.110	.106	*
Occupation of mothers	.545	.131	.184	***
Occupation of fathers	-.001	.144	-.000	
Income of family	.196	.126	.074	

(Altschul, 2012, p. 23).

Parental Interest Mediating the Relationship between Socioeconomic Status and Academic Performance of Students

The second model investigated the degree to which parental involvement mediated the impacts of socioeconomic status on 10th grade students' test points and explained 20% of the variation in 10th grade students' test points (Altschul, 2012, 20). Table 2 illustrated the direct path coefficients for the second model. Although parental involvement was included in this model, maternal occupation continued to exist as a strong predictor of 10th grade students' test scores, with a standard regression coefficient of $\beta = .184$. When parental involvement variables were included, fathers' education emerged as a significant predictor of 10th grade students' test points with a standard regression coefficient of $\beta = .106$. Remaining predictors of students' test points included, in order of magnitude, a standard regression coefficient of $\beta = .174$ for parental help with homework, $\beta = .115$ for educational resources at home, $\beta = .110$ for extracurricular instruction, $\beta = .096$ for parents' talking about and discussing school issues with their children and $\beta = .091$ for enriching activities (Altschul, 2012, 20). Parents' interest in their children's education seemed to mediate the impacts of family income and mother's education on their students' test points. Family income and mothers' education did not predict students' test scores significantly any longer after the addition of parental interest variables. Nevertheless, parental interest in education did not seem to mediate the impacts of maternal occupation and paternal education on academic performance.

Socioeconomic status significantly predicted elements of parental interest in education with percent of variance explained in parental interest variables. Socioeconomic status explained and identified 26 % of the variance in providing educational resources as parental involvement, 18 % of the

variance in providing enriching activities, 14 % of the variance in providing extracurricular instruction opportunities, 09 % of the variance in talking about and discussing school matters with children, 09 % of the variance in helping with homework and 05 % of the variance in engaging in school organizations (Altschul, 2012, 20). Although family income significantly predicted parental involvement variables, only two of these variables significantly mediated the impacts of family income on students' test points. The impact of family income on students' test scores was mediated by a standard regression coefficient of $\beta = .028$ for educational resources and by a standard regression coefficient of $\beta = .014$ for extracurricular instruction. Although certain indirect impacts of family income through providing enriching activities, helping with homework, and holding school-related conversations and discussions were not significant, magnitude of each indirect impact was comparable to the indirect influence through extracurricular education and thus provided a contribution to the overall indirect impact of family income on their students' test points. The absence of a remaining significant impact of family income indicated that parental interest variables mediated its impacts on the test points of 10th grade students. Parental involvement variables seemed to mediate the impacts of mothers' education on students' test scores. The impacts of mothers' education on students' test points were mediated by ensuring children with educational resources and extracurricular instruction. Significant indirect impacts through both variables were displayed by the standard regression coefficient of $\beta = .016$ for educational resources and $\beta = .023$ for extracurricular instruction

Discussion

The present study examined the impacts of multiple socioeconomic status items on students' educational achievement using a large national dataset. The study also explored whether parental involvement in education mediated the impacts of socioeconomic status items on academic performance of students. The results of the study displayed that socioeconomic factors predicted students' academic success and seemed to be compatible and consistent with the findings obtained from previous studies (Portes & Rumbaut, 2001). The research widened the knowledge base, which showed that various elements of socioeconomic status had distinct impacts on students' academic performance and were most predictive of students' academic achievement. Furthermore, the research findings revealed that parents' interest in education played a crucial role in mediating the impacts of certain elements of socioeconomic status on educational and academic performance of students.

It was indicated that the combined impact of socioeconomic status factors investigated in this study was comparable to the impact size of socioeconomic status estimated in a meta-analysis (Şirin, 2005) on the academic performance of students in minority samples. Findings displayed here demonstrated that

the mother's occupations had a much stronger positive influence on students' academic performance as compared to other measures of socioeconomic status. On the other hand, family income had the second strongest impact on students' academic performance. Education levels of mothers and fathers were positively associated with students' academic performance. Nonetheless, the father's occupation was not directly linked to students' academic success or parental interest.

Parent Interest in Education Mediating the Impacts of Socioeconomic Status on Academic Performance of Students

Parents' interest in their children's education played a significant role in accounting for the impacts of certain elements of socioeconomic status on students' academic achievement. The impacts of family income and mothers' education on students' academic performance were almost completely explained by parental interest factors. That being said, parental involvement did not largely mediate the impacts of mothers' occupation and fathers' education. Two components of socioeconomic status, namely family income and mothers' education, were constantly associated with children's cognitive and academic outcomes (Bradley & Corwyn, 2002). The fact that parental interest mediated the impacts of socioeconomic status on students' educational performance supported the significance of parental interest in education so as to transfer and convey the advantages and disadvantages of socioeconomic status to children. Furthermore, it was enlightening and educative to examine the strong positive impact of mothers' occupation, which could not be extensively accounted for by factors of parental involvement. Mothers most likely asked their children to work hard and struggle in terms of their parental expectations and wishes to motivate them to be successful educationally and academically and to do well in the future (Bacallao & Smokowski, 2007). Conversely, mothers' human and social capital could enhance through work and employment, and this, in turn, could contribute to students' higher academic achievement.

In terms of pathways from different elements of socioeconomic status to students' academic performance, findings displayed that fathers' and mothers' socioeconomic resources were associated with students' academic performance through distinct mechanisms. When fathers had higher levels of education, they talked about and discussed school-related topics with their children more often at home, and children sought help with homework from their fathers more often. When mothers had higher levels of education, they allocated more time and spent and invested more money in educational resources, extracurricular instruction and enriching activities for education of their children. Here, parents were more engaged in school organizations. These pathways from parents' socioeconomic status to students' academic performance demonstrated that mothers and fathers could be involved in and

engaged with their children so as to increase and improve their educational development and academic performance. Employing their economic, social and human capital as part of their interest in the education of children and adolescents, parents spent and invested both time and money in providing services, activities, materials and experiences that could benefit and contribute to their children's educational and academic development and success. Previous studies generally defined the different roles assumed by mothers and fathers in families (Crockett et al., 2007; Parra-Cardona et al, 2008), and the findings in the current study particularly highlighted the distinct roles mothers and fathers played in their children's education.

Linking Socioeconomic Status to Academic Performance of Students through the Family Stress Model and the Parental Investment Theory

Both the family stress model and the parent investment theory postulated the impacts of parental involvement on the education of children and adolescents. These theories stressed that family processes were associated with socioeconomic status and emerged as significant resources of supports and barriers, or opportunities and limitations for children's and adolescents' academic performance. Then again, certain pathways from socioeconomic status to students' educational and academic performance through parental interest in the education of their children and adolescents indicated that, as with younger children (Gershoff et al., 2007), processes related to spending and investing both time and money might be more widespread and more effective compared to processes linked to family stress. Parents' spending and investing both time and money in the education of their children and adolescents, such as ensuring educational resources, enrichment activities, and extracurricular instruction, predominantly mediated the pathways from family income to students' academic performance. By the same token, ensuring children with educational resources and extracurricular instruction mediated the impacts of mothers' education on academic development and educational achievement of children. It was asserted that as mothers' education levels increased, better-educated mothers were able to spend both more time and money and invest more in the education of their children and adolescents. Yet, lower-income parents were more likely to experience the stress and tension that might emerge on account of economic difficulties and might be linked to a shortage or lack of financial resources, especially leisure time. It was asserted that lower-income parents spent less time helping with homework and engaging their children and adolescents in enriching activities as a consequence of these stresses and tensions. When considered together, these findings suggested that academic performance of children and adolescents might increase when parents were able to spend and invest both time and money in the education of children and adolescents. Hence, parents' providing their children and adolescents with services, activities, experiences and materials that could benefit and

contribute to the educational development and academic performance of students gained importance. The economic, social and human capital as well as resources available and accessible to parents might play a critical and vital role in promoting, nurturing and enhancing the educational development and academic performance of children and adolescents.

The finding that parents' providing help to students with homework was linked to lower academic achievement points seemed compatible and consistent with the results of a meta-analysis of 50 studies examining parental interest throughout middle school. The said meta-analysis discovered a negative relationship between parental help with homework and students' academic performance (Hill & Tyson, 2009). Researchers proposed two possible explanations for the association between parental help with homework and lower academic success scores: (1) The low academic achievement of the students might cause parents to help more with their homework. (2) Parents might interfere with and obstruct adolescents' autonomy while providing help with homework. It is underlined that attention should be taken and importance should be given to other forms of parental interest in education participating in the research when commenting this finding in the current study. It was stated that when parents were engaged in one type of interest, they were more likely to engage in other forms of educational parental interest. This research provided findings that could inform both future research and interventions to develop and enhance students' academic performance. Future research should focus more on and evaluate the impacts of multiple elements of socioeconomic status on students' academic performance. Education levels and occupations of mothers and fathers may lead to different impacts on students' academic performance. Individual resources of parents, rather than shared family resources, may influence the manner in which each mother or father engages with children and adolescents.

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Chapter 4

EXAMINING THE FUTURE OF INNOVATIVE EDUCATION THROUGH A BIBLIOMETRIC ANALYSIS: TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) IN THE LENS OF INDUSTRY 4.0¹

Gamze MERCAN²

Zümrüt Varol SELÇUK³

Pınar KÖSEOĞLU⁴

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2 Dr., Hacettepe University, gmercn@gmail.com, <https://orcid.org/0000-0001-5515-999X>

3 PhD Student, Hacettepe University, zumrutvarolselcuk@gmail.com, <https://orcid.org/0009-0003-0825-2213>

4 Prof. Dr., Hacettepe University, Faculty of Education, koseoglu@gmail.com, <https://orcid.org/0000-0002-6222-7978>

1. Introduction

The exploration of progressive educational paradigms is crucial for enriching the body of literature that enhances the quality of education. As a result, a myriad of instructional approaches have evolved, primarily influenced by technological shifts. These technological advancements have catalyzed the swift expansion of knowledge, and with the onset of the fourth industrial revolution in information and communication domains, the accelerated pace of knowledge dissemination is pressuring educational bodies to be more adaptable, inventive, and forward-thinking (Shakhman et al., 2020). Consequently, educational realms must strategize to stay abreast of the swift technological shifts and the implications of the fourth industrial revolution. This entails amalgamating facets like technology, pedagogy, and content in education, encapsulated in the notion of technological pedagogical content knowledge (TPACK).

Historical investigations regarding the TPACK framework indicate its potential to amplify the caliber of educational outcomes (Eng & Conch, 2019; JM Santos & Castro, 2021; Absari et al., 2020). The TPACK paradigm has piqued the interest of academic circles in education due to its capacity to guide educators on the judicious and effective implementation of technology within the learning milieu. Therefore, there's a pressing need to systematize the extant literature concerning TPACK to discern the constituent elements tethered to it. The allure of TPACK rests in its holistic integration of pivotal educational components, like technology, pedagogy, and content (Valtonen et al., 2017; Bingimlas, 2018; Mulbar et al., 2018).

As illustrated in antecedent literature, grasping the critiques and assessments of the model's applicability, along with its developmental trajectory, is paramount. This discourse provides an exhaustive overview of the prevailing literature corpus. In relation to the empirical utilization of TPACK, a tally of 305 scholarly articles has been documented between 2018 and 2022.

The TPACK framework endeavors to coalesce pedagogical insights with tangible scenarios in the light of contemporary technological applications (Harris et al., 2009; Muhammad & Maat, 2020; Santos & Castro, 2021). Nonetheless, TPACK's construct has faced skepticism for its perceived theoretical breadth and lack of pragmatism. Detractors argue that the definitions of certain knowledge domains, especially the technological facets, remain nebulous and imprecise (Cox & Graham, 2009). In contrast, numerous works have sought to elucidate and demystify the underlying tenets of the TPACK structure, highlighting the nuances differentiating its integral components (Graham, 2011; Graham et al. 2012).

Based on this context, the educational paradigm of the 21st century necessitated the reassessment of pedagogical approaches by mandating

the emergence of innovative learning models. The steadfast progression of Industry 4.0 has made it inevitable not only for industry but also for educational practice to be shaped by technological evolution and adaptation. This evolutionary process has directed educational institutions towards more in-depth, interactive, and transformative learning methods supported by technological tools. The technological transformation in the education sector has elevated the importance of pedagogical approaches like TPACK, yet there exists a lack of consensus in the literature concerning the model's applicability and components. While TPACK serves to guide teachers in the integration of instructional practice and technological tools, there has emerged a need for an exhaustive examination of the model's full capacity. The profound impacts of Industry 4.0 on education necessitate identifying the gaps and deficiencies in current literature to maximize the potential of the TPACK model. This study aims to deeply assess the position and applicability of the TPACK model in literature within the context of the reflections of Industry 4.0 in education using the bibliometric analysis method.

2. Method

The systematic and transparent methodology grounding this bibliometric literature review illuminates ideas on the fringes of knowledge. Refer to the graphic below for a step-by-step representation.

Outlined are the five stages of bibliometric analysis, as depicted in Figure 1.



Figure 1. A five-step method for bibliometric analysis (adapted from Hudha et al., 2020).

2.1. Determine Search Keywords

On September 01, 2023, the keywords “TPACK” and “teaching” were employed in the search. Web of Science (WoS) was selected due to its vast database, encompassing over 10,000 journals. As the oldest citation database, it offers an expansive range of citation and bibliographic data (Aghaei Chadegani et al., 2013). Encompassing seven citation databases, WoS aggregates data from journals, conferences, reports, books, and book series. The initial search, which incorporated “TPACK” and “teaching,” was refined by topic. This produced 798 articles; after applying language, complete article, and year count filters, 305 academic articles remained.

2.2. Initial Search Result

This step involves filtering articles to include only those relevant and listed in the WoS database. For instance, the first filter, narrowing the time frame to 2018-2022, yielded 428 articles. Subsequent filtering for English language reduced the count to 305 articles.

2.3. Refinement of Search Result

Relevant articles indexed in Web of Science (WoS) are further filtered. Excluded are those in the format of proceedings, newspapers, books, book references, and book chapters. Once these exclusions are made, the remaining data is saved in RIS format, suitable for further analysis.

2.4. Compile Preliminary Data Statistics

Data is saved in RIS format. The initial step involves verifying the elements of a complete journal article (e.g., year of publication, volume, number, pages). If any gaps are found, they are duly filled. Subsequent analysis categorizes articles by year, publication source, and publisher.

2.5. Data Analysis

VOSviewer software serves as the tool for bibliometric analysis in this study. It's an optimal choice given its efficacy with extensive datasets. Moreover, it provides diverse visualizations, analytics, and explorations. This includes generating publication maps, author maps, journal maps, or keyword maps based on interconnected networks (van Eck & Waltman 2010; Bhattacharjee 2001; Effendy et al. 2021).

3. Findings

3.1. Publication and Citation Structure

Utilizing the VOSviewer software, the study meticulously examined the frequency of keyword appearances within the designated academic scope. Notably, the most frequently occurring keywords were curated, ensuring they cater to the demands of data acquisition and analysis.

3.1.1. Bibliometric Visualizations

Bibliometric visualizations were crafted employing the VOSviewer software, illuminating network, overlay, and density mappings (Table 1).

Table 1 consolidates the comprehensive comparative findings, unraveling the juxtapositions and interrelations within the bibliometric spectrum.

Table 1. *Comparative Analysis of Search Metrics for “TPACK” and “Teaching”*

Metrics Categories	Initial Search	Refinement Search
Source	All	All
Publication Year	All	2018 – 2022
Language	All	English
Keywords	“TPACK” and “teaching.”	“TPACK” and “teaching.”
Resulting Papers	789	305

Table 2. *Top 10 Most Cited TPACK-Related Articles*

No.	Publication Year	Author(s)	Title	Journal	Cites	Publisher	Key Result/ Conclusion
1	2018	Brinkley-Etzkorn, Karen E.	Learning to teach online: Measuring the influence of faculty development training on teaching effectiveness through a TPACK lens	The Internet and Higher Education	62	ELSEVIER SCIENCE INC	Significant change in the TPACK model due to amalgamation of elements and syllabus redesign.
2	2018	Willermark, Sara	Technological Pedagogical and Content Knowledge: A Review of Empirical Studies Published From 2011 to 2016	Journal of Educational Computing Research	53	SAGE Journal	Majority of the TPACK identifications are self-reported; rare evaluations of teaching performance exist.
3	2018	Nelson, Michael J.; Voithofer, Rick; Cheng, Sheng-Lun	Mediating factors that influence the technology integration practices of teacher educators	Computers and Education	51	ELSEVIER	Alignment of TPACK and ISTE standards varies across subjects; institutional support crucial for TPACK-ISTE alignment.
4	2017	Evrin Baran, Sedef Canbazoglu Bilici, Aylin Albayrak Sari, Jo Tondeur	Investigating the impact of teacher education strategies on pre-service teachers’ TPACK	British Journal of Educational Technology	45	BERA (British Educational Research Association)	Strong positive relationship found between teacher education strategies and TPACK in pre-service teachers.

No.	Publication Year	Author(s)	Title	Journal	Cites	Publisher	Key Result/ Conclusion
5	2018	Taimalu, Merle; Luik, Piret	The impact of beliefs and knowledge on the integration of technology among teacher educators: A path analysis	Teaching and Teacher	44	ELSEVIER	Beliefs and knowledge about technology integration play significant roles; findings beneficial for in-service training.
6	2017	Admiraal, Wilfried; and others	Preparing pre-service teachers to integrate Technology into K-12 instruction: evaluation of a technology-infused approach	Technology, Pedagogy and Education	44	Informa UK Limited	Collaboration is needed to better integrate technological knowledge with pedagogical and content knowledge.
7	2018	Tseng, Jun-Jie; Cheng, Yuh-Show; Yeh, Hsi-Nan	How pre-service English teachers enact TPACK in the context of web-conferencing teaching: A design thinking approach	Computers & Education	35	ELSEVIER	Technical issues and student-centered factors influenced web-conferencing teaching.
8	2020	Mirjam Schmid, Eliana Brianza, Dominik Petko	Developing a short assessment instrument for Technological Pedagogical Content Knowledge (TPACK.xs)	Computers and Education	33	ELSEVIER	The TPACK's internal structure supports a transformative view of the model.
9	2020	Yan Dong, Chang Xu, Ching Sing Chai, Xuesong Zhai	Exploring the Structural Relationship Among Teachers' Technostress, TPACK, Computer Self-efficacy and School Support	The Asia-Pacific Education Researcher	32	Springer Link	Relationships identified among teachers' technostress, TPACK, computer self-efficacy, and school support.
10	2020	Falloon, Garry	From digital literacy to digital competence: the digital teacher competency (TDC) framework	Education Tech Research Development	69	Springer	This article introduces a conceptual framework for an expanded view of teacher digital competencies (TDC) and recommends advanced frameworks for ethical, safe, and productive digital skill development in multifaceted digital environments.

Table 1 delineates the methodological distinction between the initial and refined searches. The initial search cast a wider net, encompassing all years and languages, resulting in a more extensive pool of papers. In contrast, the refinement search, bound by specific temporal and linguistic constraints, narrowed the scope, offering a curated collection of papers primarily in English from the years 2018 through 2022.

3.1.2. Scrutiny of Relevant Contributions

A methodical approach was adopted, encompassing 305 salient articles that underscored the notable citation indices and accentuated the recurrent themes of “TPACK” and “teaching” (Table 2).

Table 2 elucidates the array of eminent articles that have informed the TPACK and teaching discourse. The patterns emerging from citation dynamics signal the evolving academic predilections.

The articles listed in Table 2 showcase a broad spectrum of research in the realm of Technological Pedagogical Content Knowledge (TPACK). They range from exploratory studies to reviews of existing literature and offer perspectives from multiple countries and academic backgrounds. Here's a deeper dive into some noteworthy aspects:

- **Evolution of Digital Competency:** The article by Falloon (2020) underscores the dynamic nature of the digital landscape, suggesting an evolved perspective on teacher digital competencies. The shift from merely understanding digital literacy to achieving digital competence indicates the growing intricacy of the digital world teachers are preparing students for.
- **Evaluation of Existing Literature:** Willermark's 2018 review offers a synthesis of TPACK research from a sizable timeframe. By highlighting studies from 2011 to 2016, it allows for an examination of trends and patterns, possibly indicating the maturation of the TPACK framework over time.
- **Real-world Application and Challenges:** The paper by Tseng et al. (2019) focuses on the practical application of TPACK in a web-conferencing context. The findings from this study are particularly relevant given the growing dependence on online education tools, and the challenges highlighted can be used to refine remote teaching methodologies.
- **Tools for Assessment:** The study by Schmid et al. (2020) emphasizes the need for robust tools to assess TPACK. As the framework becomes more integrated into pedagogical strategies, having valid and reliable measures becomes critical.
- **Technostress and its Implications:** Dong et al.'s (2020) research provides a fresh perspective by intertwining the concept of 'technostress' with TPACK. It underscores the importance of understanding and managing the challenges posed by technology, not just leveraging its advantages.
- **Comparative Analyses:** Multiple studies, such as that by Nelson et al. (2019), offer comparative analyses, contrasting TPACK with other frameworks or standards like the ISTE standards. Such comparative insights can be beneficial in identifying overlaps, gaps, and potential synergies between different educational paradigms.

In conclusion, the listed articles in Table 2 provide rich insights into the multifaceted nature of TPACK. They not only explore its theoretical foundations but also delve into its practical applications, challenges, and the tools needed for its effective implementation. As digital technologies continue to permeate classrooms worldwide, research like this remains invaluable for educators aiming to leverage technology effectively in teaching.

3.1.3. Temporal Citation Trajectories and Publisher Inclinations

The dissection of the citational patterns reveals distinct temporal landmarks, with 2017 notably registering as a year of paramount scholarly significance (Table 3).

Table 3. 10 Publishers that Publish on the Topic of TPACK and Teaching

Number	Publishers	Record Count	%
1	Springer Nature	55	18.033
2	Taylor & Francis	54	17.705
3	Elsevier	27	8.852
4	Mdpi	23	7.541
5	Emerald Group Publishing	12	3.934
6	Wiley	11	3.607
7	Frontiers Media Sa	9	2.951
8	Kassel Univ Press Gmbh	9	2.951
9	Igi Global	7	2.295
10	Sage	7	2.295

Table 3 provides an overview of the leading publishers in the domain of Technological Pedagogical Content Knowledge (TPACK) and teaching. Here’s a closer examination of the publishers.

- **Springer Nature:** Taking the lead with 18.033%, Springer Nature emphasizes the academic community's interest in TPACK. Springer has a legacy of hosting multidisciplinary journals, which probably attracts a diverse set of researchers focusing on the intersection of technology, pedagogy, and content.
- **Taylor & Francis:** Close on the heels of Springer Nature, Taylor & Francis with 17.705% indicates its strong presence in education and technology research. They have a range of journals in the education sector, explaining their dominance in this area.
- **Elsevier:** As one of the world's leading research publishing companies, Elsevier's position in the top three is not surprising. With 8.852%, they provide a significant platform for TPACK and teaching topics.
- **Mdpi:** A not-for-profit publisher, MDPI has rapidly expanded its academic publishing over the past years. Their 7.541% showcases their active

role in circulating current research on TPACK.

- **Emerald Group Publishing:** Known for its business, management, and education journals, Emerald's contribution of 3.934% emphasizes their commitment to bridging practical and academic insights in the TPACK realm.

- **Wiley:** With 3.607%, Wiley, another major global publisher, showcases its footprint in the educational technology domain.

- **Frontiers Media Sa and Kassel Univ Press Gmbh:** Both contribute 2.951%. Frontiers Media, with its open-access model, provides a platform for innovative research. On the other hand, Kassel Univ Press Gmbh's presence suggests the university press's interest in cutting-edge TPACK research.

- **Igi Global and Sage:** Each holding 2.295%, these publishers further the discourse on TPACK. While IGI Global is known for its publications in information science and technology, Sage's vast array of social science journals provides a multidisciplinary approach to TPACK.

The variety of publishers in Table 3 illustrates the interdisciplinary nature of TPACK research. It attracts interest from a broad spectrum of academic publishers, ranging from those specializing in education and technology to multidisciplinary giants. The table emphasizes the growing significance of TPACK in the academic world and the vast platforms available for researchers in this domain.

3.1.4. Publisher and Journal Dissemination Patterns

The academic sphere witnesses diverse publishing entities contributing to the evolving dialogue of TPACK and teaching (Table 4).

Table 4. *Top 20 Journals Publishing on TPACK and Pertinent Teaching Topics*

Number	Journal	Record Count	%
1	Education and Information Technologies	20	6.557
2	Computers Education	10	3.279
3	Education Sciences	10	3.279
4	British Journal of Educational Technology	8	2.623
5	International Journal of Emerging Technologies in Learning	8	2.623
6	Technology Pedagogy and Education	8	2.623
7	Sustainability	7	2.295
8	Journal of Research on Technology in Education	6	1.967
9	Australasian Journal of Educational Technology	5	1.639
10	Computer-Assisted Language Learning	5	1.639
11	Computers In Human Behavior	5	1.639
12	ETR D Educational Technology Research and Development	5	1.639
13	Frontiers in Psychology	5	1.639
14	Interactive Learning Environments	5	1.639

Number	Journal	Record Count	%
15	International Journal of Information and Communication Technology Education	5	1.639
16	Techtrends	5	1.639
17	Educational Technology Society	4	1.311
18	Frontiers in Education	4	1.311
19	International Journal for Technology in Mathematics Education	4	1.311
20	International Journal of Instruction	4	1.311

Table 4 provides a comprehensive overview of the leading journals that have published research pertaining to TPACK and relevant teaching methodologies. Several insights can be drawn from Table 4.

- **Dominant Journals in the Field:** "Education and Information Technologies" stands out as the leading journal in terms of publication volume on TPACK, with a significant lead over its closest competitors. This suggests that it might be a pivotal journal for scholars and practitioners keen on the latest TPACK research.

- **Variety of Focus:** While some journals like "Computers Education" and "Education Sciences" are expected in the context of TPACK, seeing journals like "Sustainability" and "Frontiers in Psychology" showcases the interdisciplinary nature of TPACK and its relevance across diverse academic fields.

- **Close Competition:** The record counts highlight a close competition among several journals. For instance, three journals tie for the fourth spot, each publishing 8 articles on TPACK and associated teaching topics. Similarly, a group of journals has published 5 articles, suggesting that interest in TPACK is widespread across multiple academic platforms.

- **Relevance of Technology in Education:** The prominence of journals with a technological focus, such as "Computers Education" and "Interactive Learning Environments", underlines the growing intersection of technology and pedagogy in contemporary educational research.

- **Emergence of Niche Fields:** The presence of "Computer-Assisted Language Learning" in the top 10 hints at the specificity with which TPACK might be applied in various educational sub-domains, further emphasizing its wide-ranging applicability.

In conclusion, Table 4 not only identifies the main journals for TPACK-related research but also accentuates the diverse academic spaces where TPACK is gaining recognition. For scholars and educators keen on integrating technology into pedagogy, this table serves as a roadmap to the most influential publication venues in the field.

Figure 3 showcases a visualization of a specific database network detailing the clusters within VOSviewer pertaining to the frequency and interrelation of terms and topics related to TPACK.

- **Red Cluster (Cluster 1):** Within this cluster, the keywords "PCK (n=661, Link Strength= 66)" which stands for Pedagogical Content Knowledge, and "framework (n=444, Link Strength= 65)" emerge with the highest recurrence and connection strength.

- **Green Cluster (Cluster 2):** Notably, "TPACK (n=908, Link Strength= 66)" stands out in this cluster. Additionally, the terms "technology (n=327, Link Strength= 60)" and "Teachers (n=156, Link Strength= 45)" also exhibit a high frequency.

- **Blue Cluster (Cluster 3):** Key terms associated with this cluster include "technology integration (n=243, Link Strength= 53)" and "self-efficacy (n=145, Link Strength= 42)".

- **Yellow Cluster (Cluster 4):** The term "Education (n=359, Link Strength= 61)" is the most frequently occurring keyword in this cluster.

- **Purple Cluster (Cluster 5):** The terms that capture attention in this cluster include "Model (n=186, Link Strength= 53)" and "Teacher Education (n=148, Link Strength= 46)".

These clusters collectively provide insights into the predominant themes and relationships within the realm of TPACK research. It is evident from the visualization that certain terms and topics have garnered more attention than others, emphasizing their significance in the current academic discourse on TPACK.

Enhancing the quality of education necessitates an expanded literature focusing on contemporary educational models, including the TPACK model. This investigation enriches the existing body of knowledge concerning the factors influencing the execution of the TPACK model. Additionally, this study seeks to furnish a database revolving around TPACK themes covered in WoS-indexed papers over the past half-decade by executing a bibliometric evaluation and adjusting the WoS categorization. Observations suggest an uptick in studies on this topic over the referenced period, primarily targeting prospective educators. The USA emerges as the leading contributor to this discourse, while South Korea seems to lag behind. Bibliometric results reveal five primary clusters centered on the terms "TPACK" and "teaching." Notably, Pedagogical Content Knowledge (PCK) is the foremost cluster in terms of connectivity and prevalence. To chart out the TPACK-related database, pinpointing TPACK-relevant elements becomes paramount. The bibliometric assessment underscores that the most influential constituents of the five clusters encompass PCK, model, technological amalgamation, scholastic approach,

and structural framework. Supplementary insights suggest that aspects like educator preparation, tertiary education, and career enhancement collectively scaffold the framework, amplifying the efficient deployment of TPACK. The bibliometric visualization elucidates that TPACK-related studies encapsulate components like literacy, professional growth, syllabus design, ambition, backdrop, and firsthand exposure. Furthermore, this analysis also postulates the potential influence of factors like teaching proficiency of pre-service educators on TPACK. It's evident that a vast array of determinants remains to be explored to amplify the TPACK literature. Future explorations could also pivot towards TPACK in the context of pre-service educators, elucidating how they harness and embody TPACK.

Given the constraints of this investigation, it's prudent to assimilate diverse databases, such as Scopus and ProQuest, to derive more comprehensive insights. Continued research should pivot more decisively towards TPACK, especially in the context of the elements instrumental in nurturing pre-service educators' TPACK application prowess. Moreover, this study posits that other factors, like the instructional capabilities of pre-service teachers, might bear implications for TPACK.

This exploration primarily draws from articles cataloged in the Web of Science (WoS) database that discuss TPACK within the educational landscape over the past five years. Furthermore, the year range was chosen to reflect the most recent and relevant discussions centered on TPACK in educational settings.

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Chapter 5

VIRTUAL REALITY LEARNING ENVIRONMENTS¹

Yüksel Deniz ARIKAN²

Mehmet Can GÜLER³

1 This article is derived from Mehmet Can Güler's Master's thesis entitled "Mobile Based Virtual Reality Application Development Study for Visuospatial Skills of Dyslexic Individuals", conducted under the supervision of Assist. Prof. Dr. Yüksel Deniz Arıkan.

2 Assist. Prof. Dr. Ege University - Türkiye ORCID: <https://orcid.org/0000-0002-7151-5381>
e-mail (y.deniz.arikan@gmail.com)

3 Mehmet Can Güler (PhD Stud.) Ege University - Türkiye ORCID: <https://orcid.org/0000-0002-4067-8663> e-mail (mehmet_cang@hotmail.com)

Virtual reality (VR) is a system that brings an artificial environment closer to a realistic feeling. From a hardware point of view, VR is a computer-aided simulation environment presented with an extremely high interaction structure (Knott, 2000). VR is a product produced by intertwined applications such as image editing, modelling, graphic design, and multimedia (Roussou, 2004). From this point of view, VR can be seen as simulated three-dimensional (3D) graphic models in which a user can control their viewpoints, body movements, and interact in real time and intuitively. With the help of today's technology, VR environments can present the real world in a very close way and offer the opportunity to create new fictional worlds that will enable the user to play a role almost like an active participant in a real world (Chittaro & Ranon, 2007). In parallel, it can simulate reality in cyberspace and create three-dimensional images with high educational values.

When the studies on the concept of virtual reality are analyzed, it is seen that the technology dates to 1930. For example, in 1929, Edward Link introduced the Link Trainer (patented in 1931), the first example of a fully electro-mechanical commercial flight simulator. Also, in the 1930s, visionary science fiction writer Stanley G. Weinbaum introduced a system that introduced the idea of a pair of glasses (Pygmalion's glasses) that allowed the user to experience a fictional world through holograms, smell, taste, and touch (Cruz-Neira et al., 2018). The emergence of the first immersive VR technology with a high sense of immersion is seen in the entertainment industry as Morton Heiling's Sensorama (patented in 1962), which was connected to a single-user console device designed in the mid-1950s to capture the attention of the audience. The technology integrated into the Sensorama aims to fully immerse the individual in the film, with a person watching stereoscopic films enhanced by seat movement, vibration, stereo sound, wind, and aromas triggered during the film (Heilig, 1962). It is seen that immersive VR environments, which first made their voice heard in the entertainment sector, have been frequently subjected to research and development in many different fields such as vocational education and training, entertainment, industry, cultural heritage, scientific and medical support software (Cruz-Neira et al., 2018). In parallel with this, virtual reality technologies have been frequently used for flight simulator training and exercises (Hawkins, 1995).

For many years, immersive systems have relied on cumbersome head-mounted displays and display units with limited resolution and field of view. In 1992, CAVE (Cave Automatic Virtual Environment), with its original name, created a new approach to virtual reality. CAVE consists of a cube space that can display 10 feet on each side. With projector-based stereoscopic graphics on five sides, it allowed users to experience stereo 3D with much lighter shutter stereo glasses. The system appears large enough to provide immersion for multiple people who can experience the visualization at the same time. In

the CAVE system, in addition to head tracking, the developers have introduced a control tool called “wand” to allow users to move around the virtual environment or to move in free mode to provide embodied interaction and data feedback to the users (Febretti et al., 2013).

Introduced in 1992, CAVE technology has been used in VR research for many years. An example of this is the VR-based game environment (Figure 1), which was developed with the infrastructure of viewing, guiding, and providing positive and negative feedback on students’ movements and postures during dance in the CAVE environment (Kyan et al., 2015).



Figure 1. *Cave Technology (Kyan et al., 2015)*

In recent years, researchers have faced an exponential increase in the amount of data generated by supercomputer simulations and have experienced challenges in data exploration and synthesis. As the complexity of data continues to increase, visualization tools are becoming increasingly important for researchers, allowing them to transform raw data into discovery. To examine all this data, devices such as CAVE2, which are modern versions of traditional telescope and microscope lenses and offer analysis-visualization tools using computers with increasing resolution, have been developed. In particular, the immersive systems offered by tools such as CAVE2 have been seen as an attractive option for exploring 3D spatial data such as Molecules, Astrophysics and Geology datasets (Figure 2).

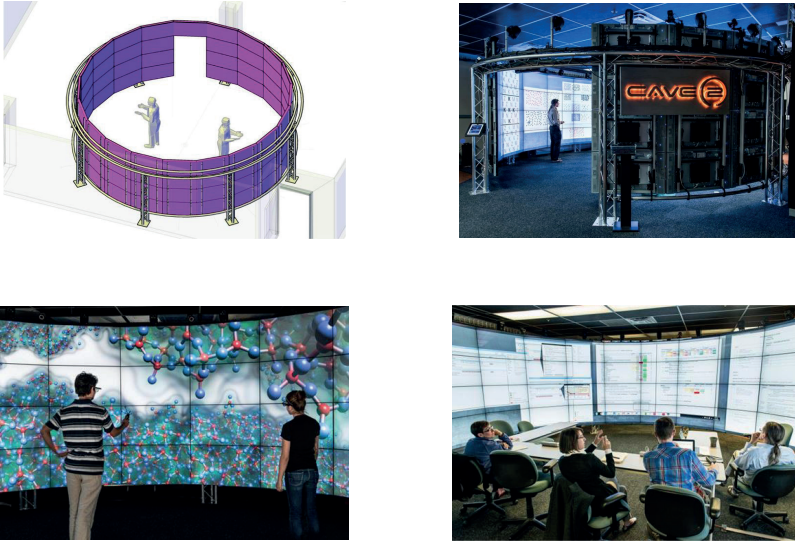


Figure 2. CAVE2 Virtual Reality Technology (Febretti et al., 2013).

The hybrid reality environments provided by CAVE2 represent the intersection of best-in-class display walls and best-in-class virtual reality environments, enabling researchers to analyse high-resolution 2D and 3D data with a unified data visualization tool. The aim of these environments is to simplify interaction transitions between 2D and 3D content and to increase the user applicability of multiple 3D applications (Febretti et al., 2013). However, immersive VR environments such as CAVE and CAVE2 have serious cost issues in terms of making them available to the end user.

VR environments generally offer a large design and usage infrastructure that varies according to the types of technology used, ranging from “fully immersive” VR environments where the user is isolated from the effects of the real world and the sense of immersion is very high, to “non-immersive” VR environments where immersion is weak. This wide range of environments, which makes a big difference in the sense of immersion, varies according to the technologies used (Daghestani et al., 2008).

Fully Immersive Environments

Fully immersive VR environments are those that disconnect the user from the real world and maximize the feeling of being in a virtual environment with full immersion. The devices that make these environments possible offer the opportunity to direct head movements directly in the virtual environment with the help of wearable glasses worn on the user’s head, while at the same

time, the interaction in the environment is maximized with many additional equipment such as data gloves and data vests, along with equipment that can be simulated in the virtual environment that can be worn on the joints. In the virtual environment, which is included with the help of wearable glasses, apart from this equipment, many devices such as orientation devices for displacement in the environment, other wearable devices that increase the sense of sensation, wearable haptic gloves that increase the sense of movement in the environment, etc. offer interaction opportunities. In this way, the sense of being in the VR environment is noticeably different from the other two types of environments. This environment is seen as disadvantageous in terms of device weight, usability in space and price items compared to other environments. However, this environment, which reflects the least problem to the individual in terms of health, can meet more with the end user with the help of the opportunities offered by the developing technology.

Semi-immersive Environments

Semi-immersive environments are computer-aided VR environments that can reflect high level performance. Semi-immersive environments are environments where the virtual image is projected directly to the user by placing it directly in the real world with multiple screen projection capability. In semi-immersive environments, the user does not use wearable gloves, vests, or VR environment controllers as in immersive environments. The VR environment experience is transferred to the user through screen display and projection mode. The high-performance computer integrates the graphical elements of the virtual environment into the real-world scene. In this way, the user cannot input or interact with the objects on the screen, but observes the image projected to the real world. In addition, the user can view the projected images in this environment with the help of 3D glasses.

Non-immersive Environments

Non-immersive VR environments offer the user the opportunity to use a desktop computer-based environment. The images to be transferred in the relevant environment are projected to the user with the help of high-resolution monitors or projection devices. In this environment, unlike the other two environments, there is no use of glasses, and the user watches the images projected to him with the support of imaging devices during his real life. In this way, your interaction with the real world continues. In the related VR environment, in contrast to semi-immersive environments, the user's input to the environment is made possible with data gloves or controller devices like immersive environments. In this environment, the user can interact directly with objects in virtual environments with devices with motion tracking technology such as Microsoft Kinect or by using the keyboard. Non-immersive environments

are the system with the least immersion structure in virtual environments. The differences between the feeling of being in a virtual environment, the levels of interaction in virtual environments and their costs are shown in Table 1.

Table 1.
VR hardware/software and impact table

	Fully Immersive Environments	Semi-immersive Environments	Non-immersive Environments
Resolution	High	High	Medium-Low
Immersion (feeling of being present in the environment)	Very high	Medium-High	Low
Interaction	Low	Centre	High
Cost	Low	Close to high	High

The effectiveness of virtual environments is analyzed in three dimensions as shown in Table 1. In virtual environments, the features related to the user’s sense of presence in the environment, the feeling of interaction and the budget requirement created by its use vary according to the devices used during the simulation of the environment. In the process of including the user in the virtual environment, the working principle of virtual environments is divided into two main parts: displaying the environment (output) and creating interaction in the environment (input). The devices developed in the display and orientation dimension of VR environments and frequently used in commercial and academic research are presented in Figure 3.

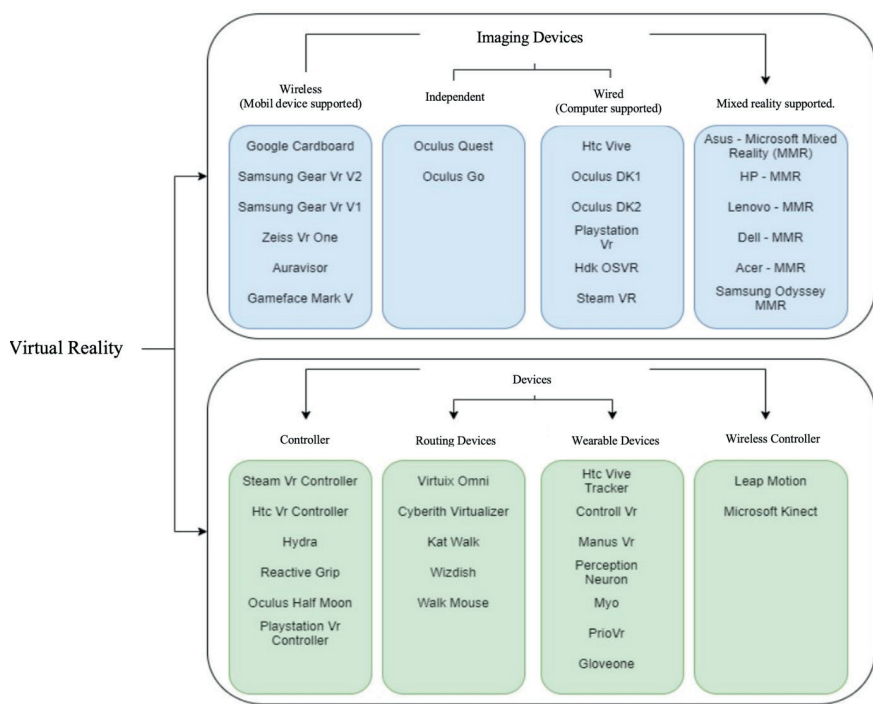


Figure 3. *VR ecosystem*

However, in studies on the applications of VR in the learning process, it is stated that non-immersive virtual environments show negative effects such as nausea, dizziness, and headache in users. For this reason, the direction of the studies has turned to immersive VR environments. One of the most important details in this orientation is the cost of technologies in VR environments. VR devices and development device costs are shown as the main reason why non-immersive VR environments are used more in learning environments. However, it is stated that the adaptability of existing immersive VR systems to learning environments has increased in line with rapidly developing technologies. While desktop VR environments show limitations in terms of possible movement activity environment, stand-alone VR devices eliminate the limitations in mobility (San Chee & Hooi, 2002).

Application Development Environments

In addition to various programmes, Unity3D, Visual Studio Community 2020 and SketchupMake programmes, which are offered free of charge, can be used in the VR application development process. In the SketchupMake programme, which is the free version of the Google Sketchup programme, models are made for applications. For other models that are not produced in the

Google SketchupMake programme, free and open products are offered in the Unity3D Asset Store. In the Unity3D game editor ecosystem, models such as buildings, vehicles, plants, and trees etc. are offered directly in the application by downloading from the Unity Asset Store, which was created in parallel with the acquisition of free available products.

The general structure of the educational game environment is created with the help of Unity3D game editor. In the content of this programme that directs the general structure, positioning of 3D objects, use of cameras, camera and 3D object interactions, artificial intelligence management, navigation network, use of animators, preparation of animations, integration of software files that will interact with objects, etc. many elements are studied. In general, Unity3D environment plays a role in the most important points such as combining all elements of the educational game in the application development process and creating a usable application.

Visual Studio Community, one of the three main programmes in the application development process, is a software interface that allows the use and development of C# software language in parallel with the Unity game engine. The related interface can be used free of charge. All software files required for applications are developed in this programme and integrated into the Unity3D game engine. In the integration process, the software files developed specifically for the applications in the Unity3D game engine include many points such as interactions, artificial intelligence, animation system, transition between bird's eye view and first-person cameras and camera movements, score structure, etc.

Virtual Reality and Education

In K-12 and higher education, VR technology was introduced in the early 1990s with projects such as Science Space, Safety World, Global Change, Virtual Gorilla Exhibit (Figure 4), Atom World (Figure 5) and Cell Biology (Figure 6).



Figure 4. Virtual Gorilla Exhibit VR Application (Allison et al., 1997)



Figure 5. Atom World VR Application (Youngblut, 1998)

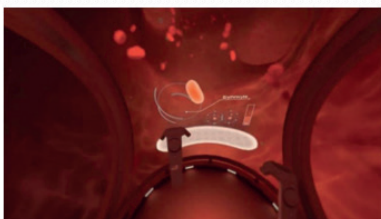


Figure 6. Cell Biology VR Application (Parong and Mayer, 2018)

Figure 6. Cell Biology VR Application (Parong and Mayer, 2018)

In these early studies, peripherals such as head mounted glasses, haptics and bodysuits were used in the design and implementation process. It is known that the first fully immersive VR environments integrated with peripherals were CAVE (Cruz-Neira et al., 1993), in which projection was made on specially designed panels on the walls of a cubic room.

The sharp development of Internet technology and the rapid evolution of VR technologies have dramatically increased the usability of VR environments. Developments have enabled the use of low-cost peripheral devices such as headsets, wearable glasses, and data gloves, and have increased design efficiency. In addition, with the further development of web technologies, new possibilities have emerged that allow multiple users to work collaboratively in a virtual environment (Kamel Boulos and Wheeler, 2007).

While VR technologies continue to offer new possibilities and challenges to VR environments, empirical evaluations on the effectiveness and usability of desktop and mobile VR environments in education, as well as other related studies, are ongoing (Merchant et al., 2014). At this point, it is expected that the number of studies will increase, and systematic research will be conducted. Research on VR technologies is not only for mobile devices, but also has a broad structure targeting smartphones and desktop applications in education

and training. In this process, the main goal with the developing technology is to develop and offer glasses in the dimension of reaching students at affordable prices. In addition, to accelerate the popularity of VR in educational environments, research draw attention to the weakness of educational content that offers virtual experiences. In addition to vocational trainings such as surgical intervention training, collaborative industry trainings, it is emphasized to transform VR applications into consumable resources in formal education environments. VR offers opportunities for learning scientific concepts in formal education environments with an approach that focuses on students' motivation and excitement. VR leads to an understanding that will eliminate the blurred distinction between 3D and 2D in learning environments (Merchant et al., 2014). At this point, it is seen that there is a tendency towards 360 video production and applications from rapidly developable multimedia content. VR comes to the forefront in the content creation process thanks to its ability to provide a sense of immersion in applications and its rapid adaptability to smartphones (Martín-Gutiérrez et al., 2017).

VR offers new ways to increase retention in learning and teaching environments. For example, VR can provide positive results for the student in terms of the amount of effort and speed of overcoming obstacles against learning information in classroom learning activity. Depending on the effectiveness of the material, the decrease in cognitive load in the learning activity increases the interest in learning and increases the active time for learning (Mayer, 2008; Wentzel & Miele, 2016). The use of immersive VR environments, especially in scientific knowledge learning, is based on interest theory and self-efficacy theory (Wentzel & Miele, 2016; Schunk & DiBenedetto, 2016).

A student with high individual interest will be more motivated to learn more about the subject. However, it is emphasized that a technology that highly increases immersion and immersion, such as VR, will be exciting for students and can increase a student's situational interest more than traditional lessons (Parong & Mayer, 2018). Self-efficacy theory states that when students see themselves as competent for the task, they put more effort and are motivated (Schunk & DiBenedetto, 2016). This process is also conveyed as influencing the process at one's own pace and direction and taking the process as a feedback loop regarding behaviors. VR games, which include the processes of progressing at their own pace for progress in academic content, determining task options, and progressing with increasing success in the feedback system in tasks, are seen to be effective on this system. Accordingly, certain interactions within a lesson can provide appropriate feedback that increases the student's self-efficacy, which in turn can increase the student's motivation for the lesson.

As a result, it is important to understand the instructional designs and direct their effectiveness in the process of integrating VR, which can be seen as a good material for teachers, into learning environments. Despite the increase

in research, there is no clear vision in educational practices in terms of creating VR learning environments. The main reasons for this are the resistance to the integration of innovative approaches into traditional educational environments and the resistance of teachers to get out of their comfort zones despite learning innovative technologies. However, as Martín-Gutiérrez et al. (2017) state, the rapid evolution of mobile technologies, especially smartphones and tablets, makes VR environments more suitable for educational institutions and students.

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Chapter 6

**THE ROLE OF SOCIOECONOMIC
STATUS, COGNITIVE ABILITY, HOME
ENVIRONMENT AND SELF-EFFICACY OF
INDIVIDUALS IN THE DEVELOPMENT OF
EDUCATIONAL INEQUALITIES**

Turhan ŞENGÖNÜL¹

¹ Doç. Dr. Ege Üniversitesi, Eğitim Fakültesi, Temel Eğitim Bölümü, Sınıf Eğitimi Anabilim Dalı

Introduction

Research argued that socioeconomic status (SES) and social class had a strong impact on children's education. However, individual differences in cognitive abilities across socioeconomic strata and social classes could not fully explain this impact. During the educational life and educational path, individual and family factors could play a crucial role in educational life of children. A longitudinal study examined 6174 first-born and second-born twins in the same family, grouped in three age cohorts as 11, 17, and 23 years in order to explain emerging, developing and enhancing of educational inequalities in children through school advices and university entrance and attendance. The current study referred to educational inequalities in terms of school recommendations for children and university entrance and attendance. Theorists and researchers explored and discussed whether the parental social class and parental socioeconomic status and cognitive abilities children of, as well as the quality of the families' home setting and the self-efficacy of the children, played a role in emerging, developing and enhancing of educational inequalities and whether they could explain these inequalities. Educational inequalities were indicated at each important point along the educational life and educational path. It was asserted that as parents' socioeconomic status increased, children's cognitive abilities became significantly less important. Children from families in high socioeconomic status were often recommended to start and continue in upper secondary education despite having low cognitive ability scores. Contrarily, in the cohort of older children, the association between children's cognitive abilities and their university entrance and attendance enhanced and strengthened as socioeconomic status of parents increased. Whereas, children with high cognitive abilities from families in low socioeconomic status were rarely able to start and attend university. Moreover, as self-efficacy of children and better home environment increased, educational recommendations that children could follow also increased and improved. The home environment could amplify the impact of social class and socioeconomic status on the formation and development of educational inequalities. Studies asserted that the academic potential and strength of children from families in low socioeconomic status were exhausted, wasted, and weakened.

Deary and colleagues (2007) indicated that family factors such as socioeconomic status of parents (OECD, 2018) and individual factors such as intelligence of children could predict children's educational outcomes. Few studies simultaneously explored socioeconomic status or social class and intelligence of children, and their independent contributions to emerging educational inequalities, as well as their united interaction influences, to have a better comprehending of the emerging and enhancing of educational inequalities (von Stumm, 2017). Educational inequalities emerged when students' educational consequences were related to their socioeconomic status and social class

background, over which students had no control (OECD, 2018). Otherwise stated, when students' social background, socioeconomic status, social stratum and social class impact determined their education, school success did not depend on individual talent any longer. The current study aimed to examine how educational outcomes developed among children from varying social backgrounds, socioeconomic statuses, and social classes. Socioeconomic status of parents, children's cognitive abilities, the quality of home setting as well as the children's self-efficacy were put forward as possible mechanisms that could explain the formation and development of educational disparities. In a large representative sample of families contained twin children from childhood to early adolescence, the study was able to demonstrate particular educational disparities at key points during the educational life and educational path. Inequalities in initial educational decisions, such as secondary school path recommendations, were examined on a sample of 6174 twins, while decisions about later educational transitions, such as attending university, were examined on a sample of 1966 twins.

Educational System

Children started elementary school at the age of 6 within the framework of education systems. Students received their educational advice at the age of 10, after the fourth year of primary school. Educational recommendations showed the proper type of secondary school for children and were ensured by elementary school teachers. Students received recommendations to start and continue "Gymnasium" as upper secondary education, "Realschule" as middle secondary education, and "Hauptschule" as lower secondary education. The degree of educational advice could show variations depending on the students' state. In some cases, children were required to outperform a trial lecture or a standardized test in order to go a higher than advised type of secondary school. In other cases, the decisions about which type of school children should go and continue could be made by the parents independently irrespective of the educational recommendations of the teachers. While the lower secondary school and middle secondary school were finished after grade 9 or 10 and allowed and enabled vocational education, the upper secondary education could guide children more academically and they finished secondary education after grade 12 or 13 with the "Abitur", as a matriculation exam or a high school exit exam. Students could gain admission to university education with this matriculation exam or high school exit exam (Eckhardt, 2019). After their placement in diverse types of schools, a shift between secondary school types, such as from middle secondary school to upper secondary school, occurred more seldomly in the first years of school (Ditton & Krüsken, 2010). Nevertheless, it was probable to go to after completing "Realschule" (Biewen & Tapalaga, 2017). All in all, 41, 2 % of all "Gymnasium" students passed the "Abitur" as a matriculation or high school exit exam in 2015 (Destatis, 2020a). 26 % of all students finished

a university degree in 2018 (Destatis, 2020b). It was probable to study at a university without achieving the “Abitur” as a matriculation or high school exit exam. Although more rarely, following vocational education made it possible to work in a related subject (Bocksch, 2020).

Impacts of Cognitive Ability and Social Class or Socioeconomic Status on Education

It was asserted that academic success and educational levels of children should principally depend on individuals’ educational abilities and aptitudes rather than socioeconomic status. Kriegbaum and colleagues (2018) and Roth and colleagues (2015) revealed that cognitive ability predicted school grades well ($r = 0.43$). A meta-analysis indicated that the relationship between intelligence and school grades was $r = 0.44$ ($\rho = 0.54$) at all grade levels, which implied that approximately 20-30 % of the variation in school grades could be elucidated by differences in intelligence (Roth et al., 2015). Even after graduating from school, students who possessed higher cognitive ability had a tendency to achieve better grade averages compared to students with lower cognitive ability points and were much more likely to graduate from university (Rohde & Thompson, 2007). Researchers suggested that aside from children’s cognitive ability, socioeconomic status of parents could also play pivotal roles in facilitating and enabling or restricting and hindering educational opportunities and academic achievement. Harwell and colleagues (2017) and Sirin (2005) indicated that children exhibited better performance at school when socioeconomic status of the children’s parents occurred higher ($r = 0.25$). Children born into and raised in families in lower socioeconomic status were less likely to go and continue university. Even if students from various socioeconomic status and social class backgrounds performed equally well in school (Heine, 2010), in their studies, Papageorge and Thom (2016) and Sackett and colleagues (2012) indicated that they most likely performed more poorly at university compared to their peers born into and raised in families in higher socioeconomic status. With respect to the distribution of socioeconomic status and social class diversity, or socioeconomic disparity between Germany, the United States, and the England, the index in 2017 was 0.36 for the England and 0.39 for the United States, whereas Gini coefficient of Germany stood at approximately 0.39 since 2008 (OECD, 2020).

Socioeconomic status and social class of parents and cognitive ability of children were moderately correlated ($r = 0.28$). The differences, inequalities and gaps in educational success and academic performance among children from varying socioeconomic origins, socioeconomic status and social classes could not be fully and sufficiently elucidated by diversities in cognitive ability of individuals (von Stumm, 2017). Studies revealed that children whose parents had very high vocational status could receive six times more an advice

for gymnasium or upper secondary school than children of parents in low vocational status. These diversities tended to be highly persistent even when cognitive abilities of children were checked (Arnold et al., 2007). In another study, Hußmann and colleagues (2017) stated that children from parents in low-vocational status had to demonstrate significantly higher educational and academic performance than children from parents in high-vocational status in order to take an advice for upper secondary education. It was observed that these inequalities of opportunity increased a lot during the last 20 years. Baumert and colleagues (2006) and Bos and colleagues (2003) indicated that as a consequence, even after placement in secondary schools, cognitive abilities of children significantly differentiated and overlapped between various types of secondary schools. More recent research focused on diversities between children within families, employing a sample from a large twin family study or TwinLife Study, and explored the combined effect of parental socioeconomic status and cognitive abilities of children on the educational passing to secondary school. The research also stated that families in high socioeconomic status could not fully compensate for the cognitive diversities between siblings within the same family, implying that children with lower cognitive abilities tended to have less chance for passing to upper secondary school than their siblings (Gil-Hernandez, 2019). The educational and cognitive problem that children with fewer cognitive abilities had less chance for passing to upper secondary school than their siblings was reflected in the large differences in overall passing rates between families in low socioeconomic status and families in high socioeconomic status. The results could be interpreted within the context of large educational disparities between families and the general ability to compensate for the cognitive deficits of children with the help of socioeconomic status. The assumption that the lack of children's cognitive abilities could be compensated with the aid of socioeconomic status was not fully supported and confirmed by the fact that both siblings participated and continued on the educational and academic path within a family. However, it was emphasized that children from families in high social class or socioeconomic status were generally more likely to attend and continue the educational and academic path. A much earlier study suggested that both parental socioeconomic status and students' cognitive abilities had an impact on planning for university, going to university, and graduating from university (Sewell & Shah, 1967). Both socioeconomic status of parents ($r = 0.35$) and students' cognitive abilities ($r = 0.36$) appeared to affect university graduation to about the same extent. Cognitive ability exhibited a stronger effect on university graduation ($r = 0.28$) than socioeconomic status ($r = 0.13$) when individuals who later started and continued university education were taken into the scope of the analysis. This showed that at the time when this study was carried out, socioeconomic status of parents previously played a stronger role in students' passing to university (Sewell & Shah, 1967). Cognitive abilities of students generally strongly influenced their educational

success and academic performance and final exam grades from the very starting to the final of the academic term. However, even the strongest relationship between students' cognitive abilities and their educational and academic performance points left more than half of the changes in educational life or educational path and academic achievement measures unexplained. Although it remained unclear to what extent students' cognitive abilities and socioeconomic status of parents made an independent contribution to estimating educational and academic consequences, when compared to students' cognitive abilities, the impact of parental socioeconomic status appeared to slightly decrease and socioeconomic status of parents could explain about 10 % of the variation in educational trajectories and academic achievement.

Taken together, (1) the current study proposed that socioeconomic status exerted an impact on education of children regardless of children's cognitive abilities and (2) it emphasized that differences in cognitive abilities could not explain the educational differences observed between children from families in high socioeconomic status and families in low socioeconomic status, which might lead to inequalities in educational opportunities. Indeed, differences in cognitive abilities could not explain the educational and academic success differences, inequalities and gaps between children from families in high socioeconomic status and families in low socioeconomic status caused by inequalities in education opportunities in the society. Further research should be carried out to investigate variables that might elucidate differences between families in various socioeconomic status. It was expressed that there were few studies that explored parental socioeconomic status and children's cognitive abilities jointly with other constructs. Consequently, it was asserted that how educational inequalities arose and developed was not sufficiently and largely well-known. Caprara and colleagues (2011) and Hanscombe and Colleagues (2011) indicated that studies on the self-efficacy of children and the quality of home setting led to a better comprehending of the processes of educational inequalities.

Quality of Home Setting

The quality of home setting was measured and evaluated with the confusion, hubbub and order scale developed by Matheny and colleagues (1995). When home environment had more noise, crowd and home traffic patterns, it reflected lower quality of home setting. Berry and colleagues (2016) and Hanscombe and colleagues (2011) indicated that children who grew up in homes with a low quality of home setting tended to demonstrate lower educational and academic performance ($r = -0.30$). These children seemed to have a limited attention span (Dumas et al., 2005), less receptive and less insightful vocabulary, and less effective executive functioning compared to their peers who grew up in a home with a high quality of home setting (Berry et al., 2016).

Researchers suggested that children who grew up in families with high levels of home chaos were most likely to live with parents in low socioeconomic status and displayed lower cognitive abilities (Deater-Deckard et al., 2009; Petrill et al., 2004).

In general, the cleanliness of the parents' home could estimate the educational consequences of children at age 25, although parental cleanliness and children's cleanliness had only a moderate relationship. Dunifon and colleagues (2001) revealed that a positive order in the parents' home might be useful in educational path of children and might be related to a good feature structure in another fields of life.

Self-efficacy of Children

Self-efficacy is described as individuals' confidence and belief in their own abilities to carry out particular tasks that have an influence on events that influence their lives (Bandura, 1994). Individuals may demonstrate differing levels of self-efficacy in different and diverse domains of life. Individuals' self-efficacy beliefs may change along different areas (Bandura, 1997). Field-proper self-efficacy of individual or a more versatile of individual, general self-efficacy of individual measure can better predict a behavior, depending on the domain (Bandura, 2006).

Individuals who had higher levels of general or academic-proper self-efficacy were able to exhibit better academic performance both at school and at university ($r = 0.34$ for both) (Caprara et al., 2011; Di Giunta et al., 2013). In a meta-analysis, Multon and colleagues (1991) indicated that both primary and high school students who had higher self-efficacy performed better on standardized success tests and *received* better school grades. Notwithstanding the fact that socioeconomic status of parents and prior school performance were checked, children who had higher academic-proper self-efficacy achieved better and higher grade point averages (GPAs) after three years (Caprara et al., 2011). It was claimed that students were more likely to complete their university education with higher general self-efficacy and higher academic-proper self-efficacy (Robbins et al., 2004). In a meta-analysis carried out on variables that could predict university education outcomes, students' academic-proper self-efficacy could explain the additional variance, albeit to a lesser degree, when prior academic achievement and SES were controlled (Robbins et al., 2004).

Objective of the Current Study

Despite the fact that the significance and effects of socioeconomic status and cognitive ability on education of children were well documented and verified, a small number of studies explored the combined effect of socioeconomic status and cognitive competence on educational advices and university edu-

cation. Quite a few studies used representative samples and considered and addressed effecting factors beyond socioeconomic status and cognitive ability.

The current study aimed to expand in several directions both results from previous research and Gil-Hernandez's (2019) approach partly using the same sample. The impacts of parental social class or socioeconomic status and cognitive abilities of children were assessed with regard to secondary school advices and university education. The variable of starting or completing university education was participated as an additional criterion to explore the combined effect of socioeconomic status and cognitive ability along the later educational life and educational path. The study used parental income, educational level, and occupational status to measure socioeconomic status. As the main predictors of socioeconomic status, family income, education of parents, and vocation of parents each had independent influences on children's educational levels, three predictive variables, namely family income, education of parents, and vocation of parents, were combined as socioeconomic status measures. Family income, education of parents and vocation of parents demonstrated a joint effect as three predictive variables. When only one of these three socioeconomic status predictors, namely family income, education of parents, and vocation of parents, was used in the analysis, this predictor would be overestimated because it would conclude with the other predictors. As a single predictor, such as family income only, parental education only, or parental occupation only, could not sufficiently reflect the overall influence of social origin or socioeconomic status and social class, the overall effect of social background or socioeconomic status and social class could be underestimated (Bukodi & Goldthorpe, 2013).

In order to extend the review of the current study into other potentially influencing factors other than cognitive ability and socioeconomic status, the current study included self-efficacy and home setting, whose impact on education was consistently displayed in previous research conducted by Caprara and colleagues (2011) and Hanscombe and colleagues (2011). After controlling for parents' socioeconomic status or social class and students' cognitive abilities, it was explored whether the self-efficacy of students and the quality of the home setting had an impact on educational advices and university education. In order to contribute to the literature in this area, it was noted that there was a need for research that would jointly and simultaneously examine the effects of four factors, namely socioeconomic status of parents, students' cognitive abilities, students' self-efficacy and home environment, on students' education and academic achievement.

The current study (1) aimed to designate whether there were differences between socioeconomic status, strata and social classes in educational advice and university entrance and attendance, after controlling for students' cognitive abilities, and whether the association between students' cognitive abilities

and educational advice or university education displayed variations between socioeconomic status, strata and social classes. For educational advice, it was asserted that cognitive abilities might play a more crucial role for students from families in low socioeconomic status. Hußmann and colleagues (2017) indicated that children in low socioeconomic status needed to perform better than children in high socioeconomic status in order to receive an advice for higher secondary education. Arnold and colleagues (2007) reported that children from families in low socioeconomic status were less likely to take an upper secondary school advice than children from families in higher socioeconomic status, even when cognitive abilities were checked. It was highlighted that there were almost no specific studies that allowed for hypotheses about differences in impact between socioeconomic status, strata and social classes, and therefore hypotheses remained explanatory for university entrance and attendance. (2) The study also aimed to test how non-cognitive predictors could contribute to a better comprehending of the association between socioeconomic status of parents, cognitive abilities, and educational pathways of children.

The current study (1) hypothesized that socioeconomic status and social class of parents and children's cognitive abilities were associated with educational advice and university education. It was asserted that the impact of children's cognitive abilities on educational advice and university education demonstrated differences between socioeconomic status, strata and social classes. (2) The study also hypothesized that self-efficacy of children and home environment were associated with educational advice and university education as two predictors, after controlling for children's cognitive abilities and socioeconomic status of parents.

Research Method

Research Sample

The research sample was obtained from the continuing longitudinal twin-family research, *TwinLife Study*, in which roughly 4100 families with same-sex twins participated (Monkediek et al., 2019). *Twin Life* sample consisted of four groups of twin pairs aged 5, 11, 17, or 23 at the initial evaluation and was used to provide a representative picture or description of families, regarding factors such as socioeconomic status and place of residence (Brix et al., 2017). Although households might be slightly overrepresented academically and educationally, particularly in younger age cohorts, the sample was sufficient to be utilized in the analysis of economic, social, cultural and educational inequalities across various social distributions and divisions (Lang & Kottwitz, 2017). Data from the Twin Life Study were used in line with the objectives of the research (Diewald et al., 2019).

Variables in Research

Socioeconomic Status of Parents

The socioeconomic status of the families was evaluated using four different predictors, according to parental income, parental education and parental vocational status. Parents' education levels were determined and assessed according to the international standard classification of education (UNESCO, 1997). The international socioeconomic index of vocational status (Ganzeboom et al., 1992) and Goldthorpe' class scheme were employed to determine and assess the occupational status and social classes of parents. this scheme included the highest occupational or vocational class of parents. In order to evaluate family income, monthly net income of families was investigated and classified according to the changing equal and equivalent scale of OECD (OECD, 2013). The calculation of the overall socioeconomic status point was based on the above predictors and was accepted for this study. For multilevel analysis, socioeconomic status was scaled to values between -2.78 and 2.55 and converted into a "z" score.

Children's Cognitive Abilities

The study employed the revised culture fair intelligence test (Weiß, 2006) to test cognitive abilities of children and to determine their cognitive ability scores. The culture fair intelligence test is defined as a nonverbal cognitive ability test that can measure basic intelligence based on Cattell's concept of fluent intelligence (Gruber & Tausch, 2015). The test includes 56 items grouped into four subtests: figural reasoning 15 items, figural classification 15 items, matrices 15 items, and reasoning 11 items. In the current study, the internal consistency of the culture fair intelligence test was determined as $\alpha = 0.84$. The total scores of the children's cognitive abilities were calculated for each subtest. For analysis, these four subtest total scores were converted into a composite score and a z-score, and scaled to values between -3.55 and 2.09.

Educational Recommendations for Children

Here, three types of secondary schools, Hauptschule as lower secondary school, Realschule as middle secondary school and Gymnasium as upper secondary education could be recommended to children, Information about these educational recommendations for student cohorts aged 5, 11, 17 or 23 was provided by parents in the current study. In the two age cohorts, namely adolescence and early adulthood, twin students self-reported existing educational recommendations. Despite the fact that the rate of recommendations for lower secondary education was slightly underrepresented and the rate for upper secondary education was too little overrepresented in the current study, the distribution of recommendations complied well with the overall distribution of students going and continuing these types of secondary school from

Grade 5 to Grade 10 (Destatis, 2012). This was in conformity with the too little overrepresentation of the household academically in the Twin Life sample (Lang & Kottwitz, 2017). All in all, the rate of students going and continuing upper secondary school has enhanced in recent decades (Statista, 2008).

Children's University Entrance and Attendance

For the variable of starting and studying in university, individuals were coded as "1" if they had a university degree. As the "early adulthood" group was too young to provide individuals who had begun university education, they were able to finish their university degree. At the time of testing, students who had just started and continued university were coded as "1" and were participated in the analysis.

Quality of Home Setting

The study used the confusion, hubbub and order scale (Matheny et al., 1995) to determine the environmental confusion and chaos within families. It contained six items including (1) "have a regular bedtime routine," (2) "You can't hear yourself think in our home" (3) "It's a real zoo in our home", (4) "We are usually able to stay on top of things", (5) "There is usually a television turned on somewhere in our home", and (6) "The atmosphere in our house is calm". Environmental confusion and chaos within families were measured and assessed using a five-point Likert scale ranging from "not at all true" to "absolutely true". Internal consistency was determined as $\alpha = 0.68$.

In the current study, parents as well as children answered the scale questions and an overall point was calculated for each family according to the responses provided by all family members. Each item was averaged to determine this overall score along different family members, and then these item averages were combined to obtain an overall home setting point for each household. Household scores for the home setting were converted to z-scores, with a higher point corresponding to a higher quality of the home setting. The z-point was then scaled to values between -4.83 and 2.04.

Self-efficacy of Children

The study used general self-efficacy short scale developed by Beierlein and colleagues (2012) based on Bandura's (1977) definition of the self-efficacy of the individual to measure the self-efficacy of children in Twin Life. Children's self-efficacy was assessed based on three items, such as (1) "I can rely on my own abilities in difficult situations", (2) "I can solve most problems on my own" (3) ". All items were assessed on a 5-point Likert scale ranging from "does not apply at all" to "fully applies to me". Internal consistency of the overall scale was determined as $\alpha = 0.71$ and each child's responses to these three items were added up for the overall self-efficacy point. Total scores for multilevel analyzes

were converted to z-scores and a higher point indicated higher self-efficacy of the children. The z-point was then scaled to values between -4.59 and 1.79.

Results

Descriptive statistics and intercorrelations

The study included 6174 participants, 55.8% of whom were female. Descriptive statistics are shown in Table 1. In general, 12.3% of students took an advice for Hauptschule as lower secondary education, 30.4 % for Realschule as middle secondary education and 57.3 % for Gymnasium as upper secondary education. A total of 58.2 % of 1966 students involved in the anlysis were female. Of these participants, 31.9 % went and continued university or had a university education degree. As for the distribution of students with regard to socioeconomic status, 29.3 % of them had grown up families in medium socio-economic status and 58.4 % in high SES families, whereas the percentage of students who had grown up in low SES families was 17.2 %.

Table 1 Socioeconomic status, children’s cognitive abilities, educational recommendations to children, university entrance and attendance, home setting and children’s self-efficacy

	Total N = 6174		Female N = 3446 (55.8 %)		Male N = 2728 (44.2 %)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Children’s cognitive abilities	37.57	8.32	37.41	8.08	37.77	8.62
Home setting	23.67	3.10	23.72	3.19	23.60	3.00
Children’s self-efficacy	11.63	1.88	11.46	1.88	11.85	1.87
	Low (< -1)		Middle (-1 to 1)		High (> 1)	
Socioeconomic status (SES)	% 19.0 Low SES		% 62,7 Middle SES		% 18,3 High SES	
Educational recommendations (for upper secondary school)	% 30.2		% 57.3		% 80.5	
University entrance and attendance (YES) (only “early adulthood” cohort)	% 17.2		% 29.3		% 58.4	
	Lower secondary advice		Middle secondary advice		Upper secondary advice	
University entrance and attendance (YES) (only “early adulthood” cohort)	% 4,3		% 19.0		% 57.8	

Note: 6174 individuals participated in the analysis. Descriptive statistics were calculated employing mean values and standard deviations. Points were scaled from 8 to 55 for children’s cognitive abilities, from 8.67 to 30 for home environment, and from 3 to 15 for children’s self-efficacy (Paulus, Spinath, Hahn, 2021) , p. 5).

The sample was separated into first-born pairs and second-born pairs in order to calculate the correlations. Table 2 displays correlations for socioeconomic status of parents, children's cognitive abilities, educational recommendations to children, university entrance and attendance, home setting and students' self-efficacy.

Table 2 *Correlations for socioeconomic status, children's cognitive abilities, educational recommendations to children, university entrance and attendance, home setting and children's self-efficacy*

			First-born twins above the diagonal					
			1	2	3	4	5	6
Second-born twins	1	Socioeconomic status	-	0.269**	0.360**	0.283**	0.308**	0.061**
	2	Children's cognitive abilities	0.263**	-	0.354**	0.356**	0.155**	0.161**
	3	Educational advices to children	0.372**	0.359**	-	0.454**	0.279**	0.087**
	4	University entrance and attendance	0.274**	0.351**	0.466**	-	0.169**	0.068*
	5	Home setting	0.308**	0.168**	0.281**	0.169**	-	0.146**
	6	Self-efficacy of children	0.054**	0.179**	0.092**	0.110**	0.131**	-

Notes. **. Correlation is significant at the 0.01 level, *. Correlation is significant at the 0.05 level. (Paulus et al., 2021, p. 6).

Correlations for the first-born and second-born twins were largely comparable. The greatest correlation between socioeconomic status of parents and children's cognitive abilities was found to be as $r = 0.266$. Parental socioeconomic status was more strongly correlated with the variable of educational advice to children ($r = 0.366$) than the variable of university entrance and attendance ($r = 0.279$). Home setting was more closely correlated with the variable of educational advice to children ($r = 0.280$) than the variable of university entrance and attendance ($r = 0.169$). Then again, children's cognitive abilities were almost equally correlated with the variable of educational recommendation to children ($r = 0.357$) and university entrance and attendance variable ($r = 0.353$). The correlation between socioeconomic status and home environment was determined as $r = 0.308$. Children's self-efficacy variable was low but significantly correlated with the variable of educational recommendation to children ($r = 0.090$) and children's university entrance and attendance variable ($r = 0.089$).

Table 3 Multilevel analysis of Model 1 and Model 2 for educational recommendations to children

	Educational recommendations to children					
	Model 1			Model 2		
		z	p		z	p
Intercept	1.423	117.092	0.000	1.428	116.828	0.000
Parental socioeconomic status	0.218	18.460	0.000	0.184	14.710	0.000
Children's cognitive abilities	0.189	18.788	0.000	0.174	17.051	0.000
Parental SES x Children's cognitive abilities	- 0.044	- 4.718	0.000	- 0.037	- 3.680	0.000
Home environment				0.111	8.928	0.000
Children's self-efficacy				0.016	1.974	0.048
Children's cognitive abilities x Home environment				- 0.022	- 2.262	0.024
Children's self-efficacy x Parental SES				- 0.001	- 0.119	0.905
Self-efficacy of children x Home setting				0.002	00.231	0.817
Residual variance (σ^2_{rij})	0.116	16.127	0.000	0.106	13.503	0.000
Residual variance in the intercepts (σ^2_{u0j})	0.272	27.456	0.000	0.261	26.159	0.000
Residual variance in the cognitive ability (σ^2_{u1j})	0.013	1.942	0.052	0.011	1.595	0.111
Residual variance in the self-efficacy (σ^2_{u2j})				0.008	1.794	0.073

(Paulus et al, 2021, p. 6).

Table 4 Multilevel analysis of Model 1 and Model 2 for university entrance and attendance

	University entrance and attendance					
	Model 1			Model 2		
		z	p		z	p
Intercept	0.265	20.238	0.000	0.255	19.046	0.000
Parental socioeconomic status	0.088	7.202	0.000	0.080	6.167	0.000
Children's cognitive abilities	0.139	12.579	0.000	0.135	13.030	0.000
Parental SES x Children's cognitive abilities	0.045	4.956	0.000	0.032	3.488	0.000
Home environment				0.021	1.771	0.077
Children's self-efficacy				0.013	1.545	0.122
Children's cognitive abilities x Home environment				0.016	1.850	0.064
Children's self-efficacy x Parental SES				0.007	0.688	0.491
Self-efficacy of children x Home setting				0.015	1.587	0.112
Residual variance (σ^2_{rij})	0.087	14.635	0.000	0.086	13.955	0.000
Residual variance in the intercepts (σ^2_{u0j})	0.071	8.604	0.000	0.068	8.155	0.000
Residual variance in the cognitive ability (σ^2_{u1j})	0.010	2.935	0.003	0.011	2.696	0.007
Residual variance in the self-efficacy (σ^2_{u2j})				0.001	0.145	0.885

(Paulus et al, 2021, p. 6).

Discussion

The current large representative study established that parents’ social class location and socioeconomic status location and cognitive abilities of children

were significantly correlated. Parental socioeconomic status and social class as well as children's cognitive abilities influenced the educational opportunities, educational life and educational career of children early on. It was emphasized that although this was a predictable finding (von Stumm, 2017), representative samples using multi-level, multi-construct approaches to explore the influence of parental social class and socioeconomic status on educational opportunities, educational life and educational career of children were rare and scarce. For children's early educational passing or transitions, their self-efficacy had a small but significant impact; however, it was not significant for later educational transitions. The home environment was considered as a subjective predictor of household conditions, which was a relevant construct for emerging, developing and enhancing of educational disparities in initial educational decisions beyond more objective predictors of socioeconomic status.

The current study determined that the higher the parental socioeconomic status and the cognitive abilities of the children, the more likely it was that the children would receive Gymnasium recommendations as upper secondary school and would be able to attend, continue or complete university. Educational recommendations for children from families in low socioeconomic status were heavily dependent on their cognitive abilities. Nevertheless, children's cognitive abilities played a more minor role for children from families in higher socioeconomic status. The fact that the educational recommendations made to children in low socioeconomic status heavily relied on their cognitive abilities and that children's cognitive abilities played a more minor role for children in high socioeconomic status was tried to be explained by the following phenomenon: Children from families in low socioeconomic status needed and had to put up better academic performance in order to receive Gymnasium advice as upper secondary education compared to their peers from families in high social class and socioeconomic status (Hußmann et al., 2017). It was asserted that children from families in high socioeconomic status could more receive Gymnasium education as an upper secondary education than children from families in low socioeconomic status even when individuals' cognitive abilities were checked (Arnold et al., 2007). On that account, children's cognitive abilities might play a more important and vital role for children from low socioeconomic status compared to their peers from families in high socioeconomic status.

Conversely, the association between cognitive abilities of children and children's college entrance and attendance increased with the rising socioeconomic status of parents despite the fact that highly intelligent individuals from families in low socioeconomic status were sparsely studied. It was asserted that this impact might be due to the fact and phenomenon that children from families in low socioeconomic status were less likely to go and continue university compared to children from families in high socioeconomic status even

when they showed equally good school performance (Heine, 2010). Moreover, it was stressed that the decision to go and continue to university was not only dependent on the cognitive abilities of the individuals, but also on their idea of whether the resources were adequate. In this way, cognitive abilities might seem less important for children from families in low socioeconomic status, while the limitation or lack of resources might emerge as a more important barrier. Children from families in low socioeconomic status might think that they could not increase financial resources themselves, even if they were eligible to start and attend university over a level of cognitive ability. Therefore, they believed that they were less likely to go and continue university despite having higher cognitive abilities. Accordingly, cognitive abilities might be less important for children from families in low socioeconomic status.

At the upper end of the socioeconomic status distribution, the study discovered significant educational inequalities in the initial educational decisions that were seemingly given utmost importance and emphasis families in upper socioeconomic status. Children from families in high socioeconomic status received largely preferred positive, advantageous and favorable educational recommendations. Parents in high socioeconomic status strived to compensate for low cognitive abilities of their children. Children from families in low socioeconomic status might encounter a systematic disadvantage, while their peers from families in high socioeconomic status faced a systematic advantage. Therefore, during transition to secondary school, which was partly based on performance and mirrors and shows social origin, socioeconomic status and social class to a certain degree, the first choice, selection, early elimination and educational inequalities emerged in the education system. In contrast, the effort and the impact exerted by parents in high socioeconomic status to compensate for the low cognitive abilities of children in the passing from primary to secondary school in the early educational life and educational career could no longer be true in a likewise manner in the transition to university in later educational life and educational career. The educational inequalities and gaps observed could not be elucidated by diversities in cognitive ability between socioeconomic strata or social classes, given that even highly intelligent individuals can show great variations in university entrance and attendance depending on their socioeconomic status. Children could be held captive in the disadvantages, negativities and limitations of being born into and raised in families in low socioeconomic status. It was emphasized that it was hard to compensate for these disadvantages, negativities and limitations. It was suggested that the processes of being born into and raised in families in low socioeconomic status even with a high level of cognitive ability operated like holding children captive. It was also emphasized that it was difficult to minimize, compensate for and eliminate the negative effects of economic, social, cultural and educational disadvantages, limitations and difficulties on children, as well as cognitive,

academic and educational damages and losses stemming from low socioeconomic status. A high socioeconomic status, a high socioeconomic stratum and social class seemed necessary as a basic resource for children so that they could realize the potential and power of high cognitive ability and could start and continue university, thanks to the economic, social, cultural and educational capital and opportunities provided by this high social class. It was asserted that high cognitive ability alone would not be sufficient on its own. For this reason, children from families in low socioeconomic status encountered strong and severe disadvantages in their passing to university education.

These results were compatible and consistent with Harwell and colleagues' (2017) and Roth' (2015) research findings based on a large sample containing diverse age groups and reporting that parents in high socioeconomic status could compensate for low cognitive abilities among families. Educational recommendations to children seemed to be more dependent on parents' in social class and socioeconomic status and less dependent on children's cognitive abilities regarding school performance (von Stumm, 2017). Sackett and colleagues (2012) indicated that socioeconomic status of parents could better predict children's university entrance and attendance when compared to work performance; thus, parents in low socioeconomic status did not seem to act more like an obstacle in front of university education rather than affecting academic performance.

The study established that as the quality of the home setting developed, the number of children who received upper secondary school advices also enhanced. Explaining educational inequalities increased as far as home environment was concerned. Model 1 demonstrated that with only two predictors, children from families in high socioeconomic status achieved a 2.38 times higher expected value for the educational advice in the range of low cognitive ability than children from families in low social class and socioeconomic status. Model 2 indicated that the anticipated value in the low cognitive ability range for children from families in high socioeconomic status was 1.75 times higher compared to children from families in low social class and socioeconomic status, when only the high quality household cohort was taken into account. Thus, it was seen that the quality of the home setting had a greater impact on families in low socioeconomic status.

The impacts of low socioeconomic status were somewhat reduced when children had a high quality home environment despite being born into and raised in families in low socioeconomic status. Contrarily, home environment did not have a significant impact on university entrance and attendance. It appeared likely that individuals' ability to choose and shape their own environments and settings might increase with advancing age. The home environment provided by the parents could play an increasingly smaller role in children's lives as they grew older. The current study determined that the influence of the

parent-provided home setting on educational recommendations to children was of similar magnitude as Berry and colleagues' (2016) and Hanscombe colleagues' (2011) studies that employed school success as a measure.

It was emphasized that the significant impact of the home setting on the education of children was important as a reflection of the first and foremost impacts (Boudon, 1974). In their studies, Karlson and Holm (2011) reported that the first and foremost impacts pointed to a more indirect impact of socioeconomic strata and social classes because of cultural diversities and variousness, whereas the secondary impact displayed a more direct impact of educational decisions on children's education. Children in high socioeconomic status were able to perform better in school compared to children in lower socioeconomic status, even with the same level of intelligence. This was attributable to first and foremost impacts such as better support from parents, opportunities to access to and benefit from resources, and better learning environments in families in higher socioeconomic status (Schindler & Reimer, 2010; Watermann, Daniel, & Maaz, 2014). The home setting could offer and represent only one direction of the learning setting. Children were able to learn better in homes which offered better home environments thanks to greater calmness, quietness, peace and a better family structure. On this account, they performed better in school. Therefore, it was asserted that all-day schooling and education could reduce the first and foremost impacts, such as better support of parents, access to and benefit from resources, and better learning environments families in families in high socioeconomic status by providing equal supportive learning environments for all students. Hence, it was argued that the impact of the parent-provided home environment might diminish, leading to a reduction in educational inequalities. Strietholt and colleagues (2015) and Züchner and Fischer (2014) indicated that since all-day schools have undergone differentiation and become heterogeneous to find reliable impacts today, it was proven that all-day schools and the method of education could not reduce educational inequalities and were less promising to do so.

Just like socioeconomic status, the quality of the home setting could also be a resource that could allow and enable individuals to maximize their capacity and reach their full potential. Examining the quality of the home setting could demonstrate that even if the quality of the home environment was a subjective indicator of household or family conditions, it was an associated construct to elucidate the mechanisms related the formation and development of educational disparities. Prior studies often considered socioeconomic status as an objective environmental measure within the family, with constructs such as family income, parental education, parental vocation or neighborhood. Nonetheless, children and their parents made a subjective assessment of the home environment in Twin Life. This particular subjective socioeconomic status indicator had a significant influence on educational consequences of children.

Future research should further examine where and how family resources are insufficient in view of the fact that socioeconomic status and home environment are not fully or perfectly correlated. This would only affect potential interventions that could not be governed by parental socioeconomic status.

The study established that children's self-efficacy had a little but significant impact on educational advices after explaining socioeconomic status of parents and children's intelligence, but no impact on university entrance and attendance. Children who had higher levels of general self-efficacy were able to have a stronger sense of control in academic learning. They were also more motivated, inspired, and demonstrated greater effort and persistence (Bandura, 2006). In their studies, Caprara and colleagues (2011) indicated that children's academic self-efficacy could be affected by previous academic and educational experiences. Nevertheless, since the impact of children's self-efficacy was significant when their intelligence was taken into consideration, the impact of children's self-efficacy could not be elucidated by better academic performance based on higher intelligence. It was seen that children's high intelligence alone was not sufficient to provide high levels of self-efficacy. It was underlined that children's self-efficacy could contribute independently to their educational consequences. However, unlike the home setting in which children grew up, their self-efficacy did not contribute to explaining educational disparities.

Future Research

In view of the fact that the current research did not check for school performance of children, school performance differences between socioeconomic strata and social classes might emerge as a factor that could affect and determine educational inequalities due to first and foremost effects (Boudon, 1974). In their studies, von Stumm and Plomin (2015) indicated that the effect of this factor could be proven by the fact and phenomenon that children from families in high socioeconomic status might display better cognitive development and greater increase and improvement in academic success than children from families in low socioeconomic status. As a result, even children with lower IQs from families in higher socioeconomic status might perform better in school, confirming upper secondary school recommendations. This hypothesis was compatible and consistent with findings demonstrating that school grades were highly correlated with the educational recommendations that were made, and that children from families in low socioeconomic status families on average scored half a school grade lower than children from families in high socioeconomic status, even at the same level of intelligence (von Stumm, 2017). Despite this piece of information available in the TwinLife Study, the analysis did not participate school grades. In any case, comparison of school grades was limited as students varied widely in age and went or continued diverse types of schools. Also, even when school grades were taken into consideration,

children from families in lower socioeconomic status seemed to be less likely to take upper secondary school recommendations than children from families in higher socioeconomic status. Moreover, children from families in low social class and socioeconomic status had to display better school performance than children from families in high social class and socioeconomic status in order to take recommendations for upper secondary school (Hußmann et al., 2017).

In order to better comprehend the formation and development of educational disparities, future research should purpose to determine subjective indicators that can mediate the impact of socioeconomic status on educational passing or transitions when intelligence is controlled. Besides, future research should investigate the home setting and self-efficacy of children to explain and shed light on the formation and development of educational inequalities. Here, researchers should focus on socioeconomic strata and social classes as sources of first and foremost impacts that can influence children's academic life, educational trajectories, and school performance. The impacts and roles of socioeconomic strata and social classes in providing better educational support to children, in accessing and utilizing educational resources, and in providing better learning environments should be investigated more deeply. Children's personalities (Poropat, 2009), academic self-concept (Marsh, Byrne, & Shavelson, 1988), intrinsic motivation and individual motivation levels (Komarraju, Karau, & Schmeck, 2009) as well as self-esteem and self-discipline tendencies (Duckworth & Seligman, 2005) should be addressed and explored in lower and higher socioeconomic strata and social classes.

School performance of children from families in lower and higher socioeconomic strata and social classes could change with the resources they had as well as the support they received from their parents. Fan & Chen (2001) indicated parental educational involvement and engagement for children's academic achievement. Benner and colleagues (2016) emphasized that parents' educational expectations from their children and involvement in school played an important role in children's academic achievement. Mischo and Haag (2002) reported that private tutoring enhanced achievement in mathematics. Flere and colleagues (2010) pointed out that cultural capital of parents contributed to children's academic achievement. Additional support such as parental educational involvement and engagement for their children, parents' educational expectations from their children and involvement in school, private tutoring in mathematics and cultural capital could all play a role in and exert an impact on children's education. Owing to the fact that some of these factors, such as cultural capital or the educational involvement and engaging of parents for children, could hardly be changed by the education system, educational disparities could never be exactly and completely eliminated or eradicated. Nevertheless, funds were allocated to higher education expenses, efforts were exerted to develop teachers' skills in spreading all-day schools and education, financial support was provided for university students from families in low socioeconomic

mic status, and more information about university entrance and attendance was transferred to upper secondary school graduates.

Conclusion

The current study determined that the quality of home setting influenced educational disparities beyond the children's cognitive ability and parental socioeconomic status at early educational decisions, but not at later educational passing or transitions. As educational disparities could not be fully elucidated even after taking home setting and self-efficacy into consideration, other factors might also play a pivotal role in the formation and development of educational disparities. Future research should explore potential factors that can play a role in the formation and development of educational inequalities and discuss what kind of measures and interventions can reduce educational inequalities.

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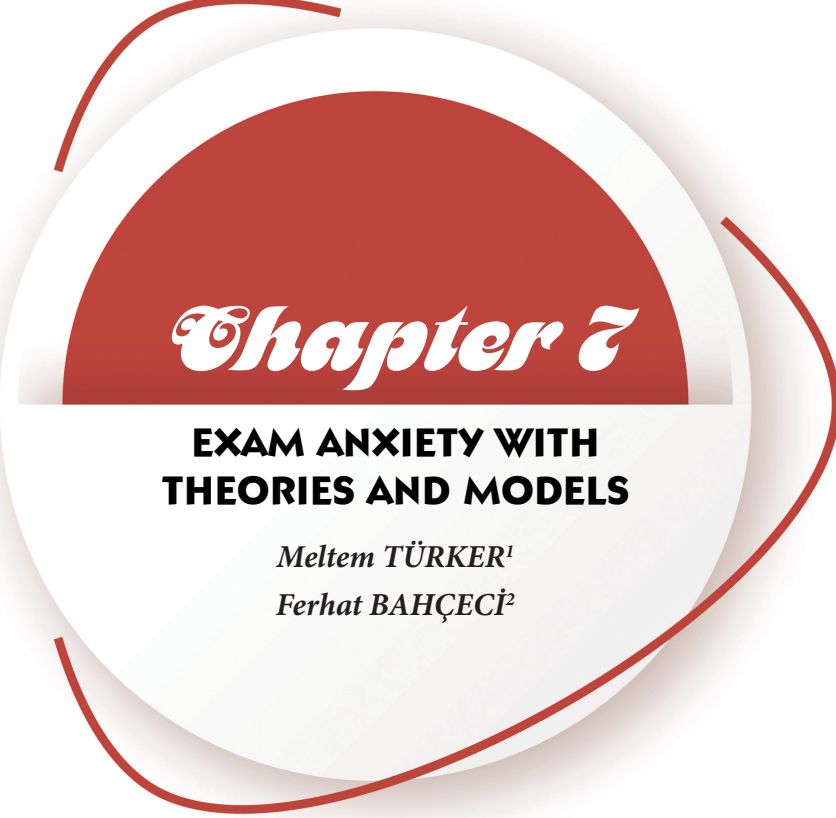
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Chapter 7

EXAM ANXIETY WITH THEORIES AND MODELS

Meltem TRKER¹

Ferhat BAHECİ²

1 Ph. D. ; Firat University. pskdanmeltemturker@gmail.com ORCID No: 0000-0002-2123-0695.

2 Assoc. Prof.; Firat University. ferhatbahceci@hotmail.com ORCID No: 0000-0001-6363-4121.

Anxiety

Although anxiety is considered by scientists in the field of psychology to be one of the main characteristics of people, there is no general definition of anxiety and it is defined in different ways. Freud (1936) defines anxiety as something that can be felt under strong and undesirable conditions, and Miller (1951) defines it as a fear-like and predefined response. (Karcıoğlu and Balkaya, 2018). In the psychological literature, the explanation of anxiety is the dictionary meaning of curiosity, anxiety and fear, which is the state of arousal caused by the physical, emotional and psychological changes that people encounter when they are stimulated (Kaya and Varol, 2004). In Budak's (2003) words, anxiety is a state of anxiety caused by uncertainty or danger, uneasiness or fear in an unfortunate encounter.

Theoretical perspectives on anxiety

Başarır (1990, p.3) pointed out that the problem of anxiety has been the curiosity of many theorists and researchers for a century and has become more systematic in the last twenty-five years. Anxiety has become the main force that forms the personality of some theories, and as a secondary factor of certain theories, it has been accepted as the emotional basis of personality development (Köknel, 1985). Anxiety also plays a role in our personality structure and behavior. Researchers and theorists have also done research on this subject. Some of these researchers and methods are given below (Öztürk, 2008).

Anxiety according to psychoanalytic theory

Freud, the first psychoanalytic theorist, first mentioned anxiety and stated that anxiety expresses the basis of personality formation (Manav, 2011). According to Freud, the first time we felt anxious was when we were born. Before birth, people will encounter an environment protected by many stimuli, such as light, noise, and heat. In order to adapt to this situation, similar reactions to anxiety attacks are seen in adults such as sudden breathing, rapid heartbeat and crying in infants (Genç, 2013). Freud made different views on anxiety over time. First, he pointed out that anxiety is first the suppression of power caused by motivation, and then it emerged in a self-destructive way based on the way one perceives oneself, and he pointed out that the mechanism of suppression can prevent this from happening (Freud, 1965). In explaining Freud's theory, Yalom (2001) stated that anxiety in the form of anticipation of the onset of helplessness is a response to helplessness. According to Freud, anxiety is divided into three categories. Accordingly, real anxiety is actually the same as fear. The individual is aware of the risky situation that causes his/her emotional reaction. Moral anxiety refers to an inner feeling that the higher self suppresses the desire of the lower self and originates from the superego.

On the other hand, neurotic anxiety disorder is concerned that the self-defense abilities of individuals in such anxiety will weaken and this will cause the defense mechanisms of individuals to be used (Burger, 2006, p.341).

Freud believes that nothing in life is coincidence. The whole point is to adapt. Individuals can survive by adapting to physically or environmentally perceived threats. However, people with neurotic anxiety disorder have lost their ability to adapt (Gökçedağ, 2001). The nature and intensity of neurological disorder differs from other types of anxiety disorder. Neurological anxiety mainly involves logic and its cause is unclear. Its history is based on infancy and childhood (Yanbastı, 1996).

According to Karen Horney, what is considered dangerous is how people feel about it. According to him, the main cause of anxiety is that people feel unacceptable in childhood. The degree of anxiety varies depending on the value attributed to the person, the importance of the danger and the effectiveness of personal defense methods (Akt., Yanbastı, 1996). Although Honey attributed her anxiety to her childhood, she also stated that this alone was not enough. People's "main concern" is their despair about nature and the power of death (Çavuşoğlu, 1993). According to him, a person can protect himself with the following four options: love, alienation, power, and surrender (Horney, 1937). According to Harry Stuck Sullivan, anxiety arises from interpersonal communication and interaction, not from the intrinsic state. For parents, empathy methods, wrong parental attitudes and punishment methods and inconsistent behaviors may cause anxiety (Akt., Gökçedağ, 2001). As behaviors and experiences diversify, infant anxiety disappears, which distinguishes and reduces anxiety (Yanbastı, 1996).

Anxiety according to behavioral theory

The basis of behavior theory is learning. The link established between stimulus and response makes learning possible (Morris, 2002). According to this theory, learning is anxiety due to experiences that arise based on internal and external influences. If the relationship established by these connections disappears, the reaction may also disappear (Sazak and Ece, 2004). The development of a conditioned stimulus that leads to anxiety reactions indicates that this process is a human learning process and that people are looking for ways to avoid it (Palti, 2012). Alyaprak (2006, p.41) pointed out that Dollar and Miller's anxiety was caused by the impulse system that individuals set up to prevent pain. According to learning method theory, anxiety resulting from the pairing of stimuli with anxiety neutral stimuli and pain stimuli becomes more common as people generalize to stimuli. The phenomenon that makes anxiety disorder a pathology is not the root cause, but its severity, frequency and importance (Öner, 1977).

Anxiety according to humanistic theory

The humanistic approach values the individual as an individual and treats people as a unique and valuable asset, and has managed to meet the needs of the time, especially from Maslow and Rogers' perspective. Various behaviors, especially those related to behavioral schools and psychoanalysis, also attracted people's attention. Humane therapy does not aim to improve neurosis, anxiety and depression, but to increase mental health and self-actualization (Schultz and Schultz, 2002). Therefore, unconditional love and positive respect, the pioneer of mental health and the importance of the family and the environment in achieving the basic needs of self-actualized individuals are emphasized. In fact, it has been observed that people who are self-aware during health development (mostly middle-aged and elderly) may also avoid neurosis (Nelson-Jones, 1982).

Anxiety according to cognitive theory

According to advocates of the cognitive school, the root of anxiety lies in people's perception and evaluation of events. Strong emotions such as anger and despair are strongly felt because of people's exaggerated perceptions. Summarize these cognitive processes by making a common connection with the experience and create models that include the prevention of personal danger. In this case, arousal occurs in a war or intervention system, and the person selectively evaluates anxiety and potential danger (Savaş, Soygüt, & Kabakçı, 2003). While talking about anxiety treatment, Yalom (2007) conveys Barlow's thoughts about anxiety as negative feedback by perceiving negative emotional expressions to varying degrees. In this structure, it has emotional and cognitive components and the event will get out of control and appear as a maladaptive solution. In this case, anxiety emerges as the basis of the thinking process and cognition.

Anxiety according to existentialist theory

Danish philosopher Soren Kierkegaard conceptualized anxiety as the content of his theory of existence. According to him, the future will cause anxiety because the structure contains uncertainty. Uncertainty is the source of anxiety. However, this is a positive situation because it supports and encourages the development of human life (Kierkegaard, 1844). According to him, man is not only a biological being, but also a being that cannot be explained by mindset alone. Considering this situation, he believes that anxiety is a way to get rid of nothingness and underlying emotions (Manav, 2011).

Rollo May, on the other hand, interpreted anxiety as a threat to human survival. According to him, anxiety is not a feeling, but a way of being. This existential crisis, including the threat of extinction, is the most painful and painful emotion that

people can experience (Çavuşoğlu, 1993). According to this school, everyone cares about existence. Death and the uncertainty of human consciousness form the basis of this anxiety. Although survival anxiety is a natural concern, unnatural reactions to survival indicate the presence of neurological anxiety (Korkut, 1992).

Irvin Yalom (2001) explained the anxiety caused by death. Therefore, the primary and main concern is death anxiety, which allows the individual to exist. Facing the reality of death is a necessary condition for real life, which makes anxiety inevitable. People can only cope with anxiety by facing death and taking responsibility for this outcome (Koçak & Gökler, 2008). Otto Rank pointed out that the outside world may feel anxious from a trusted environment (like the mother's womb) facing destructive individuals. According to him, the first condition that causes anxiety is to leave the mother's womb and start living in an unsafe world full of danger (Geçtan, 1989).

Anxiety according to Richard Alpert and Ralph Haber

Richard Alpert and his friend Ralph Haber abandoned Albert's success due to the pressure to take the exam, and under that pressure, Haber received further good marks. Therefore, there are two types of students affected by anxiety. The type of student who successfully passes the exam anxiety and fails negatively due to exam anxiety (Habacı, 2013).

In the 1960s, Richard Alpert studied and analyzed exam anxiety in his first scientific study. Although Albert said the test pressure diminished his success, his colleague Ralph Huber instead said that the pressure that existed before the test was more successful in the test and got good results from the test. Thanks to these studies and insights, Albert and Huber stated that there are two different problems. The first is the person whose success level decreases due to anxiety, and the other is the person who uses anxiety as a source of success to achieve success (Keskin, 2001).

Anxiety according to other theorists

Erich Fromm attributed anxiety to people's fear of being alone. People's loneliness, helplessness and environmental alienation are the factors that cause anxiety (Çavuşoğlu, 1993). On the other hand, Adler attributed anxiety to feelings of inadequacy and pointed out that anxiety involves feelings of inferiority (Köknel, 1989). Geçtan (2006) conveyed Cannon's view of anxiety, thinking that anxiety is a response to dangerous situations that interfere with the balance of the body and feel unable to regulate this deteriorating balance. According to the Gestalt theory put forward by Perls (1969), anxiety is the gap between the present and the future. People are trying to fill this gap with plans and expectations. People cannot live today because they are anxious (Korkut, 1992).

Exam Anxiety

Anxiety is an emotion that can disrupt people's lives and affect their lives. It is often considered a condition that affects people's behavior and also shows its own maladaptation in the school environment (Hill and Sarason, 1966). In schools, the test used to measure the success of the education system can be seen as a moment of intense anxiety. While the exam is considered an evaluation experience that students often experience, adults have been intertwined with anxiety from time to time (Bacanlı and Rider, 2006, p.12).

Test anxiety is defined as an anxiety disorder arising from the negative emotions and behaviors of failed concepts during adolescence. This anxiety begins before the test and continues until the end of the test. Another definition in exams, tests, or other assessments is that fear causes failure (Beideli Trager 1994; Dusek, 1980; Safren 2000).

Test anxiety means that people feel threatened or dangerous during any assessment. Test anxiety depends on the conceptualization of two psychological factors into context and specific characteristics. These are described as delusions and excitement. Cognition affects test anxiety cognitively; excitement is the realization of physical tension (Sarason 1990; Enright et al. 2000).

As a scientific construct, the term test anxiety refers to a set of cognitive, physiological, and behavioral responses that express concerns about possible negative consequences or test failures, or similar assessments (Sieber, O'Neil, & Tobias, 1977). And negative thoughts, feelings and behaviors arising from the possibility of failure (Kaymak, 1987). As a result of being tested, fear or anxiety may occur in individuals (Otrar, 2003).

Exam anxiety is a type of state anxiety and is the most serious obstacle for many students to achieve their goals. Since it includes behaviors that affect personal education and academic performance, lack of learning skills beyond exams, excessive physical response, and mental fatigue (Adana & Kaya, 2005).

Exam anxiety models

Researchers have created various theoretical models to explain exam anxiety. The first theory related to test anxiety was the test anxiety theory proposed by Sarason and Mandler (1952). Therefore, there are two types of reactions to the subject, not the anxiety of the subject, which is a motivational emotion. Individuals who respond to subjects reduce their anxiety by focusing on well performing tests. Individuals who respond to topics instead of focusing on exam thinking will fail due to anxiety (Akt. Aslan, 2005, p.53). Although there are many models of test anxiety, the most commonly accepted models are:

2.2.8.1. Request models

According to this model, anxiety is part of excitement. Low anxiety disorder plays a protective role. High anxiety can damage a person's self-esteem and cause them to feel unsuccessful (Doğan & Baş, 2003). According to this method, anxiety will increase the level of arousal of the person and increase the likelihood of people answering incorrectly (Zeidner, 1998).

2.2.8.2. Deficiency models

According to this model, what is worrying is not preparing for the exam, but preparing for the exam. In this approach, exam anxiety is considered the result of poor performance, not the cause of poor performance (Musch & Bröder, 1999).

2.2.8.2.1. Cognitive attention model

Wine (1971) and Sarason (1980) proposed the first theory, cognitive attention theory. According to theorists, those who have exam anxiety during the exam will succumb to their delusions and turn their attention to their thoughts during the exam instead of focusing on the exam. The result of this situation will affect the cognitive attention of the individual, negatively affect the test success performance of the individual and cause exam anxiety (Ergene, 2000; Kabalcı 2008; Özdemir, 2005).

The model consists of two different intervention variables. While negative self-perception and insufficient person perception constitute the first category, emotional dimension variables (tension, pressure, etc.) It constitutes the second category. These two sets of variables lead to anxiety and failure by distracting the individual during the exam (Ergene, 1994). Compared to physical and emotional aspects, this method attaches more importance to the cognitive aspects of test anxiety (Zeidner, 1998).

It should be noted that the difference in focus lies in the individual's different exam anxiety. Cognitive structure, cognitive disability, and the individual's negative self-perception cause the individual to experience varying degrees of trial apricots. Compared to others, those with high test anxiety paid more attention to themselves than to tasks, while those with low test anxiety paid more attention to tasks. (Damer and Melendres, 2011; Zeidner, 1995). According to Cassady and Johnson (2002, p.281), students with strong test anxiety have unrealistic internal statements about their shortcomings and failures. These personal statements about oneself distract the person and focus on things other than the exam, thus reducing the effectiveness of the individual in conducting the exam (Uşaklı and Yapıcı, 2001).

Individuals feel anxious during the test, and many ideas have nothing to do with the timing of the test. They continue to think about the test taker's opinions about themselves, the success of other test takers, and their perceptions of candidates' deficiencies (Sarason & Stoops, 1978).

Baltaş and Baltas (2008, p.99) explained this situation with the cognitive behavioral therapy model. For this reason, people resort to external reasons rather than accepting that the situation that makes them nervous is their own interpretation. Doctorates are similar to Albert Ellis' ABC model. The main cause of anxiety is that people do not understand the situation. In fact, it is thought that B causes the emotion or behavior of events from A to C. Cüceloğlu (1998, p.92) explained this as follows:

A: The teacher criticized the students for not doing their homework.
Incident

B: "If I don't do my homework on time, my relationship with the teacher will deteriorate and it will be difficult for me to prepare for the exam."
(Interpretation-approach)

A: Students feel committed to learning. (Emotions and behavior) From this, it can be seen that people's interpretation of B will affect people's feelings and behaviors towards the situation.

Lack of working skills model

The model believes that exam anxiety is caused by repeated academic errors caused by inadequate learning. Students with test anxiety have inadequate study abilities and are unable to use time and organize information effectively, thus lowering their test scores. In addition, people with sufficient business skills also experience exam anxiety (Lufi and Darliuk, 2004, p. 176). Therefore, an information processing model was created to evaluate the level of exam anxiety of students with insufficient job skills and sufficient job skills.

According to the working skills inadequacy model, exam anxiety is caused by a lack of sufficient knowledge and skills for effective work. Furthermore, students with high test anxiety often have problems with effective coding, organization, and using time (Tobias & Hedl, 1972; Zeidner, 1995; Zeidner, 1998).

Learning disorder model

Zeidner (1995) stated that those who do not have the ability to use time correctly and effective working methods experience exam anxiety. According to this theory, the repeated occurrence of academic errors due to the lack of effective study habits can lead to exam anxiety.

Lufi, Okasha and Cohen (2004) stated in their research that mastering effective working habits alone does not predict exam anxiety, and people may

feel anxiety even if they have this skill. This contradiction between knowledge led to the emergence of the third theory.

According to the test anxiety model, lack of personal test skills and inadequate coping with anxiety during the exam are the causes of exam anxiety. According to this model, the level of anxiety during the exam will increase as people realize that they are not sufficiently prepared for the exam (Lufi, Okasha, & Cohen, 2004).

Social learning model

The social learning model was developed from the traditional social learning model. In this model, the relationship between exam anxiety and self-efficacy, control and self-esteem is very important. In addition, the model also includes methods for conceptualizing individuals' thoughts about motivation and behavior (Smith, Arnkoff, & Wright, 1990).

According to Bandura, Adams, Hardy and Howells (1980, p.42), if an individual believes in himself/herself, he/she believes that he/she has knowledge and ability about the subject he/she is struggling with. Does not develop fear and anxiety. However, if a person has doubts about their knowledge, skills, and abilities, then they are plunged into fear and anxiety.

Contemporary cognitive motivation models

According to this approach, exam anxiety is related to one's negative thoughts and beliefs about oneself (Şahinler, 2018).

Self-regulation(Self-regulation) model

According to this method, exam anxiety is a dysfunctional coping method and everyone will face exam anxiety. However, the degree of this anxiety may vary from person to person (Şahinler, 2018). The model suggests that using cognitive structure methods to shape expectations will reduce anxiety (Siddique, LaSalle-Ricci, Glass, Arnkoff, & Díaz, 2006; Zeidner, 1998). The findings of Bradley, McCraty, Atkinson, Tomasino, Ountainerty, and Arguelles (2010, p.270) also support this view. Bradley et al. (2010, p.270) Students who receive self-regulation skills training can better control exam anxiety.

Self-value model

According to this model, the emotional response of the individual to failure is related to inadequacy. Since the environment in which the evaluation is made threatens the self-worth of the individual, the individual feels anxious. (Covington, 1992, p.201; Şahinler, 2018). According to this method, there is a negative correlation between ability level and exam anxiety, and research supports this result (Cassady, 2004, p.576; Hembree, 1988).

Operational models

According to this method, anxiety is related to the evaluation of the sense of danger and coping resources in a stressful environment (Goh, Sawang, & Oei, 2010).

Spielberger’s trait state anxiety model

In this method, trait anxiety is the tendency to perceive all environments as disturbing (Alisinanoğlu & Ulutaş, 2000, p.17; Öner, 1997); state anxiety is defined as a state of anxiety caused by the individual’s stress or feeling of pressure in the environment. Although exam anxiety is actually a state anxiety, it is seen that students with high exam anxiety also experience trait anxiety (Küçük, 2015; Spielberger & Vagg, 1995).

Transactional process model

According to this model, exam anxiety exhibits permanent characteristics. In addition, delusions and emotions during the test can activate state anxiety. In this dynamic process, the test environment and the individual will affect each other (Sapp, 2013; Spielberger and Vagg, 1995).

In addition to all these, many studies have been conducted to eliminate the negative effects of exam anxiety. Dixon (1996) described “systematic desensitization techniques” to test anxiety. Pless (2010) “Computer Aided Program”; Hyman (2005) conducted research on the treatment of anxiety disorders by applying “hypnotherapy”. In this sense, the difficulties faced by students can be eliminated.

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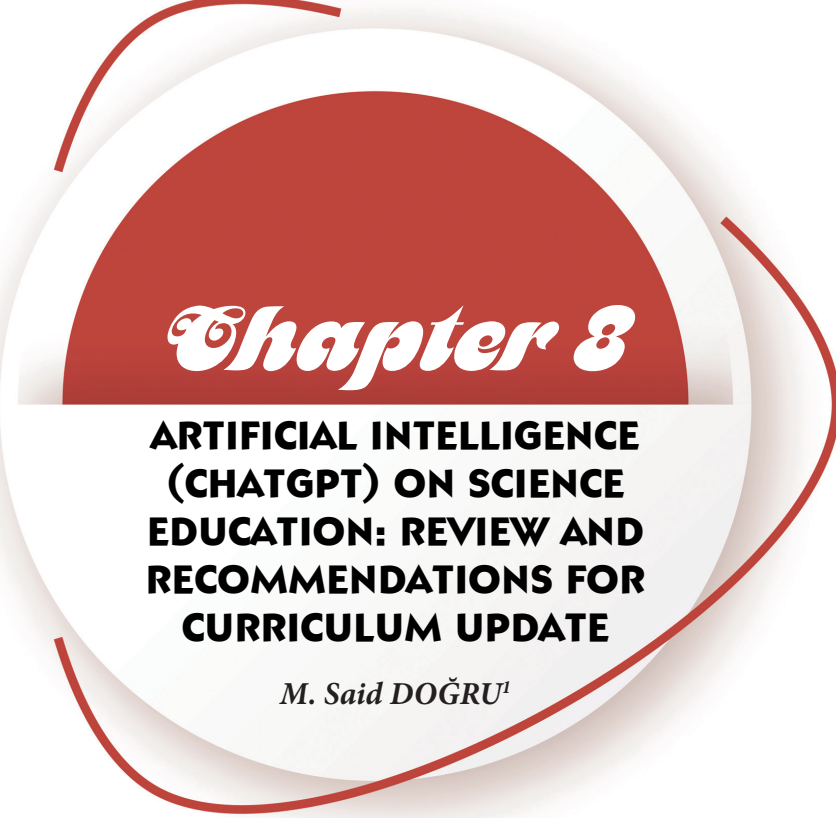
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Chapter 8

ARTIFICIAL INTELLIGENCE (CHATGPT) ON SCIENCE EDUCATION: REVIEW AND RECOMMENDATIONS FOR CURRICULUM UPDATE

M. Said DOĞRU¹

¹Dr. Lecturer, Kastamonu University, Vehicle Rafet Vergili Vocational School, msaid.dogru@yahoo.com, ORCID: 0000-0002-9516-1442.

Introduction

In our age, the rapid increase in scientific and technological developments brings with it the benefit of innovations that will be more efficient in teaching lessons. Students must keep up with this, to be informed, and to gain understanding, skills, and thoughts compatible with developments. Recent developments in informatics stand out in this context, including the recently developed artificial intelligence technology. It can be used effectively in developing and updating the science education curriculum.

Therefore, our study aims to examine the contribution of artificial intelligence to science education and its contribution to the development and updating of the curriculum. It is obvious that today, traditional education methods are insufficient, and new opportunities and methods that have emerged with technological developments must be used. This situation also comes to the fore in science education. Undoubtedly, it has become essential to research and understand the use of artificial intelligence, which has come to the fore recently in science education.

Later in the article, we will discuss in detail how artificial intelligence technologies can be integrated into science education, how they can increase student achievement, and what recommendations can be offered for curriculum updating. Additionally, we will evaluate the future of artificial intelligence-supported science education and the potential in this field.

This article aims to usher in a new era for science education and offers exciting new opportunities for science students and educators.

Artificial intelligence in science education has increased rapidly in recent years. The rapid development in three-dimensional software technology has offered the opportunity to be used in many areas (Li et al., 2017; Nocar et al., 2023). The coronavirus epidemic has been incredibly effective in education, making the use of virtual technology attractive (Golh, 2020; Raja, 2022; Stecula, 2022). Web 2.0 technology has recently brought changes in education (Johinke et al., 2023; Kulakli, 2014; Ozcinar, 2020) ChatGBT, etc., effective new generation artificial intelligence systems have been developed (Arcas, 2022; OpenAI, 2023). For example, they said using metadata in science education attracted their attention. In addition to being a virtual environment that can be used in other areas of science and education, the metaverse also helps use blockchain and smart contracts (Martin, 2012; Mikroyannidis, 2018; Ćeke, 2020). On the other hand, artificial intelligence transformation of science education can be addressed in seven ways:

1. Student-Centered Learning: Besides making science education student-centered, it provides unique information and materials for students and can provide effective learning by creating a learning environment appropriate

to their interests and levels.

2. **Teaching Support:** Science teachers can use Artificial Intelligence to monitor and evaluate students. Thus, it allows students to identify their weak and strong sides and develop an individual education method.

3. **Simulations and Laboratory Experiences:** It provides students with safe and low-cost virtual laboratory opportunities and practice opportunities through simulation opportunities.

4. **Data Analysis:** Teachers can use artificial intelligence to follow the stages and results of education studies, analyze data, and use it in future programs as well as in the development of the curriculum.

5. **Teacher Training:** Science teachers can be trained in using artificial intelligence to support education to improve their skills.

6. **Time and Space Independence:** With this method, science education is not dull and dependent on time and place, and can also offer the opportunity to learn in a comfortable environment.

7. **Preparation for the Future:** In this way, students become more adaptable to future technological developments, and their interests and skills increase. It offers the opportunity to improve oneself in these areas.

As noted above, artificial intelligence transformation provides permanent learning opportunities for teachers and students to increase their success. On the other hand, there may be problems such as ethical security in the virtual world. It is also necessary to be careful when considering this aspect and planning.

In addition, today, thanks to modern technologies, learning strategies such as 'memorization and repetition,' 'peer learning,' 'resource search,' 'study planning,' 'attention in classes,' and 'use of reminders' can be developed more effectively. These statements emphasize how technology can enhance learning strategies by expressing the same idea differently (Thurzo et al., 2023).

In education, faculties of education have a great responsibility to enrich the curriculum with basic pedagogical theory and, at the same time, to match the teaching styles with the student's learning procedures at a sufficient level. It is a fact that in this constantly developing and changing world, the science education curriculum must be handled innovatively and updated according to the needs of our age. Because fundamental changes in education also affect teaching and learning methods. If used correctly, the presence of artificial intelligence in the field of education faculty can be managed as an advantage. It is understood from the studies that the artificial intelligence primary curriculum should be implemented in science laboratories, and artificial intelligence literacy should be given more attention in schools (Zhang et al., 2023; Kong et al., 2021). In addition, it should be expanded to include courses (Kong et al.,

2021). In this way, they can critically evaluate artificial intelligence applications from an objective perspective and benefit from them as a conscious user (Lozano & Blanco Fontao, 2023).

For the science education curriculum and areas related to artificial intelligence, the following steps can be followed:

1. Review of Science Education Curriculum: First, carefully review the existing science education curriculum. It is important to understand the curriculum's topics, objectives, and learning objectives.

2. Determining the Relationship between Artificial Intelligence and Science Education: Identify potential relationships between artificial intelligence and science education. Consider where AI technologies can be applied to science education (e.g., data analysis, simulations, student assessments).

3. Defining Learning Objectives: Define the learning outcomes targeted in the curriculum. That is, clearly determine what knowledge, skills, and abilities students need to acquire.

4. Determine Where Artificial Intelligence Technologies Will Be Used: Consider what learning objectives artificial intelligence technologies can support and how they can be integrated. For example, artificial intelligence can be used in areas such as tracking student progress, creating customized learning materials, or delivering laboratory simulations.

5. Address Student Diversity: Take into account the diverse learning styles and levels of students and assess how AI applications can cater to these individual needs effectively.

6. Infrastructure Assessment: Evaluate the necessary technology infrastructure for seamless integration of AI applications, ensuring the availability of suitable software and hardware.

7. Educator Training: Provide comprehensive training for educators to adeptly utilize artificial intelligence technologies, thereby empowering them to incorporate these tools into the classroom environment.

8. Continuous Assessment and Enhancement: Consistently assess the efficacy of AI-driven science education applications and utilize feedback to refine and improve the overall learning experience.

Additionally, the use of artificial intelligence in education is a recent development. Its acceptance by teachers and students is related to the results of planned studies and practices. The contributions of artificial intelligence applications to education are significant.

In addition to these contributions, artificial intelligence is developing rapidly, and its use is rapidly spreading in many areas. In parallel, it will inevita-

bly be used in science education. However, the process of its spread may vary depending on time. This relates to how they are applied, how they are used, and their adaptation to laboratory studies and educational environments. The following changes can occur with its use in science education:

1-Being more data and evidence-based becomes more critical in planning and attitudes,

2-The use of digital education technologies such as 3D and machine learning algorithms is greater in science education.

3- Training students to understand and use artificial intelligence-based tools may be necessary.

4-Developing learning resources and curriculum on this subject.

5-Using artificial intelligence-based materials in science student simulations and applied studies.

Recent developments have clearly revealed that science education curricula should be updated in line with artificial intelligence. Because it is understood that Artificial Intelligence can significantly support teachers and learners in applied matters. However, since it is a newly developing field, its use in education is generally accepted, its benefits are revealed, and academic institutions include this technology in their curricula in the future. On the other hand, the ethical consequences of using this technology in education and educators' competence are also significant. For these reasons, it would be beneficial to be careful and seek expert opinion before including it in the curriculum.

In addition, since artificial intelligence-supported developments in terms of applications in science education are new, it cannot be determined precisely how they will be conveyed to students, as their introduction will take a while. However, it will emerge as a result of in-depth academic research and discussion of the role of artificial intelligence in education. As studies on this subject gain momentum, curriculum updates will also develop accordingly.

Intelligence in science theoretical education can have a significant impact. (for example, in the promotion and understanding of global warming) Thus, students will learn the terminology and basic information about artificial intelligence. Here are some things science students need to learn about artificial intelligence :

What is artificial intelligence, its technical terms, how to apply it, what its principles are,

2- Experts in developing technical and new aspects of education and training use this technology.

3- Since artificial intelligence is new in science education, its results, benefits, and risks will emerge over time, so more studies are needed.

4-Pre-service teachers who will use this technology in the future will already be informed about the ethics and risks that will arise.

5. artificial intelligence in education will lead to more efficient and effective teaching methods. However, it is crucial to approach the issue cautiously and consider the potential impact on students and the teaching profession.

ChatGPT

Artificial intelligence technology is rapidly developing in an extremely productive way. On November 30, 2022, AI-focused ChatCPT was made accessible to people on OpenAI's website.

ChatCPT, developed by OpenAI, is designed to respond to users' requests in a very human-like language.

It uses the Generative Pre-Trained Transformer 3 (GPT-3) database, which hosts a large set of humanoid text, to respond to users' input just like a human.

ChatCPT uses the same algorithms as other artificial intelligence to generate text for input.

The element and advantage distinguishing ChatCPT from other artificial intelligence models is that it is designed to provide more human-like and natural responses and can be developed on specific data to adapt specific responses to some applications, such as chat robots.

ChatCPT's feature of giving feedback closest to humans makes it an indispensable tool for applications that seek answers closest to humanoid speech styles, such as speech robots and virtual assistants.

However, it needs some limitations, such as the need for a comprehensive data and accounting repository to develop and activate this tool (Sallam, 2023).

Of course, there is a difference between ChatCPT, the advanced face of artificial intelligence, and GPT-3, which continues to be used today in various contexts. First of all, they were both developed to serve in different fields and, therefore, have unique strengths and aspects open to training. Although GPT-3 is more efficient in terms of performance. Faster and more efficient results can be achieved with ChatCPT than GPT-3. It is also more compatible with chatbot applications. ChatCPT is more suitable for chatbots in these aspects. All of this can be understood from the study by Atlas (2023).

The dialogue-based approach enables the new GPT to provide more realistic feedback and establishes direct dialogue for its users. Another difference of GPT-3 from ChatCPT, which was designed for this purpose, It is a feature that

aims to initiate an interaction for the user, not to establish a dialogue. It uses a method known as reinforcement learning in human learning (Alex, 2023).

Comprehensive language models have been introduced that serve the purpose of producing original-looking error-containing texts. Frequent mistakes indicate linguists' concerns that such artificial language models work fraudulently, allowing English to be learned without requiring natural language skills. As the scope and complexity of prototypes increases, it becomes increasingly difficult to document the details of the information (James, 2013; Markowitz & Hancock, 2016; Thurzo et al., 2023).

Artificial Intelligence, Academic and Legal Aspects

Artificial intelligence is advancing rapidly, but it also brings some problems. Students generally use trading programs. (synonym, correction, style guide, etc.) thus using someone else's tool and program. If using an artificial intelligence product while writing text means taking someone else's product and using it without his/her permission and without citing the source, this would also be a problem. When quoting the artificial intelligence product or from other sources, it is necessary to indicate the bibliography or make a reference. If artificial intelligence is to be cited, it is essential to obtain permission from Sabin following the conditions of the countries. For this reason, students must consider these situations when using the artificial intelligence act by the necessary procedures and principles and be informed about this. Despite all this, it is a fact that the use of artificial intelligence in science education is increasing day by day (Cooper, 2023; Darayseh, 2023)

However, in the future, it will be necessary to connect artificial intelligence with programs for writing text (using documents, word processors, etc.). Therefore, the main goal of this article is to serve as a bibliography for those who scan the literature on the topic of advancing the science education curriculum. The primary purpose of this research is to provide an analysis of the urgency of the "AI update" of the curriculum and a summary with an assessment of the current state of research on the impact of AI on science course contents in universities. Since the research on this subject is still in its early stages and is currently insufficient, and there is not enough research that can be considered productive, the aim was to guide academics who take into account the urgency and fields of the "Artificial Intelligence update" in their current curricula. The use of artificial intelligence by humans will significantly affect the world, and it seems possible to say that this impact has the potential to leave more traces than the emergence of climate change. However, it does not seem easy to provide information about the timing and scope of its impact at this time.

2. Methods

Intelligence technologies in education and science departments between 2020 and 2023, international indexes Scopus and Web of Science (WoS) databases were used. The search strategy focused on the keywords “Artificial Intelligence,” “Science Education,” and “Education.” Articles, reviews, and conference papers were reviewed as study types. The languages of the relevant publications were determined as English. The scientific community gives a very positive assessment of this document compared to similar documents. The document is evaluated by considering factors such as the number of citations, the year the document was published, the document type, and related disciplines. A value greater than 1.00 indicates that the document is cited more frequently than expected. The document’s citations are calculated based on the three-year average number of citations of similar documents. Each discipline contributes equally to this measure, balancing differences in citation patterns among researchers.

In this review, in addition to the literature review, OpenAI Inc. is based in San Francisco, CA, USA. A sizeable general language artificial intelligence model called ChatGPT developed by was used. This comprehensive language model is achieved by fine-tuning supervised and reinforcement learning methods and is based on OpenAI’s GPT- 3.5 language model. With five questions about science education, the AI was tasked with rewriting the title of this review to reflect ChatGPT’s ability to analyze the actual ambiguity of its answers. While carrying out the method and findings part of the study, Thurzo et al. (2023) were used.

3. Findings

ChatGPT was asked to rewrite the initially intended title for this article in the context of expectations for a title suitable for narrative review. The original prompt was:

Could you rewrite the following title of a scientific review, “Review of Science Education Curriculum in Terms of Artificial Intelligence (ChatGPT),” more appropriately?

Also, ChatGPT answer:

“This review aims to re-evaluate the science education curriculum, focusing specifically on the ChatGPT artificial intelligence system. The study considers in detail the impact of artificial intelligence on educational content and learning processes.”

Literature analysis results that met the selection criteria are listed in Table 1. Publications dedicated to artificial intelligence registered in Scopus and WoS and directly related to education have been increasing steadily since 2021.

Table 1 clearly shows the rates in 2021, 2022 and 2023. It has been observed that the rates increase significantly every year.

Table 1. *Information about publications covering the subject of artificial intelligence in the field of science and education*

Order	Year	Type	Number
one	2021	Research Articles	296
2	2021	Review Articles	165
3	2021	Book Chapters	74
4	2022	Research Articles	378
5	2022	Review Articles	204
6	2022	Book Chapters	128
4	2023	Research Articles	430
5	2023	Review Articles	245
6	2023	Book Chapters	118

ChatGPT, guided by five questions from the field of science education shown below, entered from easy to complex, yielded the following results:

1. What is photosynthesis?
2. What is the difference between an element and a compound?
3. Explain Newton's laws of motion.
4. What is the cell membrane, and what are its functions? Explain with examples.
5. What teaching strategies or methods would make a science lesson fun and exciting? Explain by giving examples.

1. What is photosynthesis?

'Photosynthesis is a vital biological process that occurs in plants, algae, and some bacteria, by which light energy is converted into chemical energy. It is the process through which these organisms synthesize organic compounds, primarily carbohydrates, using carbon dioxide and water, in the presence of sunlight and chlorophyll. This process is crucial for sustaining life on Earth, as it serves as the primary source of energy for most living organisms. In the process of photosynthesis, light energy is absorbed by chlorophyll and other pigments in the chloroplasts of plant cells. This energy is then used to convert carbon dioxide and water into glucose and oxygen. The general chemical equation for photosynthesis is:



In this equation, carbon dioxide and water are the raw materials, and glucose and oxygen are the end products. The glucose produced is utilized by the plant for energy and growth, while the oxygen is released into the atmosphere as a byproduct.

Photosynthesis is not only crucial for the sustenance of plant life but also plays a significant role in maintaining the balance of oxygen and carbon dioxide in the Earth's atmosphere, making it an essential process for the overall ecological balance and the survival of various life forms.'

2. What is the difference between an element and a compound?

'An element and a compound are both fundamental concepts in chemistry, but they represent different types of chemical substances.'

1. Element: An element is a pure substance that cannot be broken down into simpler substances by ordinary chemical processes. Elements are composed of only one type of atom. Each element is represented by a unique chemical symbol. Examples of elements include hydrogen (H), oxygen (O), carbon (C), and gold (Au).

2. Compound: A compound, on the other hand, is a substance that is composed of two or more different elements chemically combined in a fixed ratio. Compounds can be broken down into simpler substances (elements or other compounds) by chemical reactions. They have properties that are different from those of their constituent elements. Examples of compounds include water (H₂O), carbon dioxide (CO₂), and sodium chloride (NaCl).

In summary, the main difference between an element and a compound lies in their composition and the ways they can be broken down. Elements are composed of only one type of atom and cannot be broken down into simpler substances, while compounds are composed of two or more different elements that are chemically combined and can be broken down into their constituent elements or simpler compounds through chemical reactions.'

3. Explain Newton's laws of motion.

'Sir Isaac Newton formulated three fundamental laws of motion that laid the foundation for classical mechanics. These laws describe the relationship between the motion of an object and the forces acting on it. They are as follows:

1. Newton's First Law of Motion (Law of Inertia): This law states that an object at rest will remain at rest, and an object in motion will continue moving in a straight line at a constant velocity, unless acted upon by a net external force. In simpler terms, it implies that objects tend to maintain their state of motion unless compelled by an external force to change that state.

2. Newton's Second Law of Motion (Law of Acceleration): This law describes how the velocity of an object changes when it is subjected to an external force. It states that the rate of change of an object's momentum is directly proportional to the net force acting on it and takes place in the direction of the applied force. Mathematically, it can be expressed as $F = ma$, where F is the net force applied to the object, m is the mass of the object, and a is the acceleration produced.

3. *Newton's Third Law of Motion (Law of Action and Reaction): This law states that for every action, there is an equal and opposite reaction. When one object exerts a force on another object, the second object exerts a force of the same magnitude in the opposite direction on the first object. In other words, if object A exerts a force on object B, object B simultaneously exerts a force of the same magnitude but in the opposite direction on object A.*

These laws provide a comprehensive framework for understanding the behavior of objects in motion and the forces acting on them, forming the basis for the study of classical mechanics and serving as the cornerstone of modern physics.'

4. What is the cell membrane and what are its functions? Explain with examples.

'The cell membrane, also known as the plasma membrane, is a crucial component of all cells, serving as a selective barrier that separates the interior of the cell from its external environment. It plays a vital role in regulating the movement of substances in and out of the cell, maintaining cellular homeostasis, and facilitating various cellular processes. The cell membrane is primarily composed of lipids, proteins, and carbohydrates.

Functions of the cell membrane:

1. **Selective Permeability:** The cell membrane controls the movement of substances in and out of the cell, allowing certain molecules to pass through while preventing others from entering. This selective permeability helps maintain the internal environment of the cell and regulates the exchange of essential nutrients, ions, and waste products. For instance, in a human red blood cell, the cell membrane allows oxygen and carbon dioxide to diffuse in and out of the cell, respectively, to facilitate gas exchange in the lungs.

2. **Cell Signaling:** The cell membrane is involved in various cellular signaling processes, including reception of external signals and transmission of these signals to the cell's interior. It contains receptor proteins that can bind to specific molecules, such as hormones or neurotransmitters, triggering a series of intracellular responses. For example, in nerve cells, the cell membrane facilitates the transmission of signals from one neuron to another through the binding of neurotransmitters to specific receptor proteins.

3. **Cell Adhesion:** The cell membrane plays a crucial role in cell adhesion, allowing cells to adhere to one another and form tissues and organs. It contains various adhesion proteins that facilitate cell-cell interactions and help cells adhere to the extracellular matrix. For instance, in multicellular organisms, the cell membrane enables cells to adhere together to form tissues, such as in the case of epithelial cells forming the lining of organs like the skin or the intestine.

4. **Protection and Support:** The cell membrane provides structural support and protection to the cell by enclosing the cellular contents and protecting them from the external environment. It helps maintain the shape of the cell and prevents the entry of harmful substances. For example, in plant cells, the cell membrane, along with the cell wall, provides structural support and protection to the cell, allowing it to maintain its shape and resist external pressures.

In summary, the cell membrane is a crucial component of all cells, performing various functions that are essential for the survival and proper functioning of the cell. It not only acts as a protective barrier but also regulates the transport of substances and facilitates cell signaling and adhesion, thereby contributing to the overall stability and functionality of the cell.'

5. What teaching strategies or methods would you use to make a science lesson fun and interesting? Explain by giving examples.

'Making a science lesson engaging and enjoyable can significantly enhance students' understanding and retention of the subject matter. Here are several effective teaching strategies and methods that can make a science lesson fun and interesting:

1. **Hands-on Experiments:** Conducting hands-on experiments is an excellent way to bring science concepts to life. For instance, in a lesson about density, you can have students create their own lava lamps using oil, water, and effervescent tablets to demonstrate the concept of varying densities and the principles of buoyancy.

2. **Multimedia Presentations:** Incorporate multimedia elements such as videos, interactive simulations, and animations to illustrate complex scientific concepts. For example, when teaching about the solar system, you can use virtual reality (VR) applications to take students on a virtual tour of the planets, allowing them to explore the celestial bodies in an immersive and engaging manner.

3. **Gamification:** Integrate educational games and quizzes related to the science topic to promote active participation and enhance learning. For instance, creating a jeopardy-style game where students can answer questions related to various scientific phenomena or discoveries can foster friendly competition and encourage active participation.

4. **Outdoor Learning:** Organize field trips or outdoor activities that allow students to observe and explore natural phenomena firsthand. For instance, taking students on a nature walk to study local plant and animal species can provide practical insights into concepts like biodiversity, adaptation, and ecosystems.

5. **Collaborative Learning:** Encourage group activities and collaborative projects that promote teamwork and critical thinking. For example, assigning students to work in teams to design and build simple machines, such as pulleys or levers, can foster teamwork and hands-on learning while reinforcing con-

cepts related to physics and engineering.

6. Storytelling and Analogies: Use storytelling and real-life analogies to make abstract scientific concepts more relatable and understandable. For instance, when teaching about the human body, you can use creative analogies to explain complex biological processes, such as comparing the circulatory system to a transportation network that delivers essential goods to different parts of a city.

7. Role-Playing and Simulations: Implement role-playing activities or simulations that allow students to simulate scientific processes or historical experiments. For example, organizing a mock archaeological dig to help students understand the process of excavation and the importance of evidence collection and analysis in historical research.

By incorporating these interactive and engaging teaching strategies, educators can create an exciting and dynamic learning environment that stimulates students' curiosity and fosters a deeper understanding of various scientific concepts.'

When the answers given above by ChatGPT are examined, it is seen that the questions are ordered from easy to complex. When the answers given are examined, it is seen that the answers are listed from easy to complex, from simple to detailed.

4. Discussion

The study results are on the textual aspect of communication with ChatGPT AI. In order to understand technical science terms, it is sufficient for them to be interconnected, and the language and artificial intelligence model can make science subjects more understandable. This technology will enable teachers to communicate one-on-one with their students and provide many conveniences, such as creating virtual course content and preparing texts.

The literature analysis presented in Table 1 has shown that artificial intelligence has the potential to improve science education in both theoretical and practical areas. In theoretical education, artificial intelligence is used in individualized learning, monitoring student progress, question and answer, and customization of course materials. In applied science education, artificial intelligence, laboratory simulations, analytics and data processing, problem-solving, and modeling are used to develop students' practical skills and connect science topics with real-world applications. However, caution is required to ensure responsible and ethical use and to avoid biased training datasets.

There are several methods for integrating artificial intelligence into science education curricula. Several examples highlight the integration of artificial intelligence in science education. For instance, the utilization of AI-supported simulation tools enables the replication of science experiments, fostering a hands-on learning experience for students. Furthermore, the incorporation

of AI-driven decision-making systems in education enhances students' proficiency in making scientific judgments. Additionally, the implementation of AI-driven interpretation technologies amplifies students' capabilities in analyzing complex scientific data. In administrative operations, the integration of artificial intelligence streamlines tasks like scheduling courses and managing student records, leading to heightened efficiency and precision. These examples underscore the successful integration of artificial intelligence into the science education curriculum. The specific use of artificial intelligence may vary depending on the goals and needs of the educational institution.

Unfortunately, it is very possible for artificial intelligence technology to be misused. ChatCPT can also be interpreted as a warning that artificial intelligence is more vital than humans in some situations. It is necessary to know how many students will use artificial intelligence as a tool or whether it will be possible for educators and experts in this field to detect them. Today, ChatCPT technology can cause excitement and sometimes panic in educational environments. However, soon, it will become a standard technology like the Excel program. This situation risks the survival of humanity in some respects. Most experts think that ChatCPT will force universities to be vigilant against some of its illegal uses. As ChatCPT became more widespread, risks related to its potential use in university environments emerged. For example, Does the fact that the chatbot gives humorous, plain, and simple feedback to easy questions prevent students from cheating or quoting illegally? Especially after the introduction of the internet, students can cheat on their homework with this tool.

For this reason, some tools have been developed for teachers to detect cheating in homework. However, there are some concerns that ChatCPT will eliminate the need for these systems. Because experts do not yet have the technology to detect whether an article was written by artificial intelligence. However, a new detection tool will be developed for this shortly. For now, the only way to detect this is for teachers to recognize their students' writing languages and examine their homework. This way, instructors and artificial intelligence tools can catch inconsistencies in the studies presented (Kalhan, 2023). All this shows that Artificial intelligence will break new ground in academic studies and writings and offer technologies suitable for alternative ideas and opinions. ChatCPT is a communication tool used to reveal different ideas. Merriam-Webster.com states that "plagiarism" is the unauthorized use and dissemination of someone else's information. Artificial intelligence products may also be within this scope. Although students always prefer easy writing and quick access to results in learning, they also use writing. For this, they must develop unique ideas that do not belong to others. Still, educational change and updaters have to take into account the knowledge from the past (Wiggers, 2023). However, there may be difficulties in determining whether a product belongs to artificial intelligence. In parallel, to prevent unauthorized text transfer, OpenAI is

working to put special marks indicating their ownership in AI texts used in text output marking (Wiggers, 2023). On the other hand, AI detectors such as GPT-2 Output Detector and Writer AI Content Detector can be used to prevent artificial intelligence plagiarism (Thurzo et al., 2023).

Science curricula are much more than that, updating them in light of the current capabilities of generative and analytical AI and scenarios where AI impacts the ability to communicate with students or faculty, disseminate knowledge, write articles, understand educational or scientific texts, and many other soft skills. Basic knowledge about it will become an integral part of the theoretical curriculum. Cooper (2023) examined the reflections of artificial intelligence on science education in his study. In this study, he examined the answers given by ChatGPT to the questions it asked about science education. He found several central themes in his study using the exploratory method. He stated that fundamental ethical concerns should be considered when stating these themes and that there is a high probability of copyright violations related to them. He stated that artificial intelligence is an essential tool in science education and should be adapted to science education while using it.

Results

This review confirmed that changes in science education fields are so sweeping that their curricula need to be significantly adapted to many uses of AI. With AI-supported systems, science education can personalize students' experiences and guide the learning process effectively. This technology can help science students learn science concepts more effectively by enabling them to conduct experiments. Additionally, by analyzing students' emotional reactions to science topics, artificial intelligence can identify topics that students have difficulty with and guide teachers in developing personalized teaching strategies. In this way, science education can better respond to students' individual needs, increase students' interest in science, and undertake many tasks in this sense.

Artificial intelligence fundamentally transforms science education, but theoretical science education is closer to AI applications than clinical education, so it is better suited for curriculum updates. Artificial intelligence software that includes clinical applications represents an area where maturation processes or some use cases are still under development. Currently, while we better understand the short-term effects of AI on science education, we struggle to fully predict the long-term consequences of science education curricula.

Artificial intelligence has great potential to increase the effectiveness of science education. However, it is necessary to ensure responsible and ethical use, avoid biased training datasets, and be conscious. It has been revealed that some AI systems can be used in anti-plagiarism tools, and AI effectively de-

tects cases of plagiarism that already exist. The realization that AI can perform some human tasks may lead to backward thinking towards limiting the use of AI rather than modernizing student assessment in science education.

As a result, the impact of artificial intelligence on science education and the effects of innovations in this field on dentistry are increasing at an unpredictable pace. Different types of generative AI have changed current approaches in many areas, such as student education and assessment methods, as well as essay writing. While artificial intelligence has the potential to improve significantly various aspects of science education, it is essential to be mindful of its possible adverse effects, such as plagiarism and bias.

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Chapter 9

HOW STORYTELLING CAN INSPIRE FOREIGN-LANGUAGE STUDENTS?

Seçil TÜMEN AKYILDIZ¹

¹ Doç. Dr., Fırat Üniversitesi, İnsani ve Sosyal Bilimler Fakültesi

Defining Storytelling as the Art of Language

The process of acquiring a language often commences with the development of listening and speaking skills. Consequently, storytelling emerges as an effective pedagogical method for facilitating language instruction across many linguistic contexts. Stories are an integral components of diverse cultures, serving purposes beyond mere amusement. For Dujmović (2006), storytelling can be seen as the fundamental and earliest method of imparting knowledge and information. There exist civilizations whose traditional teaching methods remain the exclusive means of instruction. Despite various attempts to mimic or modernize it, such as the electronic narrative medium of television, the enduring popularity of live oral storytelling remains unwavering. The art of teaching is fundamentally grounded in the utilization of a straightforward narrative as its foundational element. They are employed for educational endeavors, cultural preservation, and the inculcation of moral principles. Traditional narratives serve as a means for individuals to articulate their deeply held principles, anxieties, aspirations, and desires. Oral narratives serve as a direct manifestation of a literary and cultural legacy, enabling the appreciation, comprehension, and preservation of said heritage. By means of storytelling, individuals are able to undergo an empathetic connection with historical events and develop a sense of unity with diverse contemporary societies, so acquiring a deeper understanding of the underlying motivations and behavioral patterns of humanity (p.76-77).

The term “story,” derived from the Latin word *historia*, refers to “a coherent account of significant events, particularly those that occurred in the distant past” (Webster, 1961). According to Pellowski (1990), throughout the course of history, individuals from diverse cultures have engaged in the collective act of storytelling, spanning countless generations. In the realm of language teaching, scholars typically delineate storytelling based on its mechanisms and its efficacy in fostering communication between storytellers and recipients of stories. As defined by Dyson and Genishi (1994), storytelling may be understood as a communicative process in which a storyteller employs a narrative structure, vocalization, and/or dramatic and mental imagery to engage with an audience. In turn, the audience use mental imagery to provide the storyteller with both verbal and non-verbal feedback. By Wang and Lee (2007), storytelling involves the teller’s emphasis on the primary message(s) of the narrative, allowing for the utilization of language improvisation, vocalization, mimetic movement, and creative expression to effectively communicate the intended message to the audience. As stated by Palmer (2001), a linguist who adopts a constructivist perspective, storytelling plays a significant role in the language learning process. Palmer argues that storytelling is an interactive and dynamic process that enhances many cognitive talents such as imagination, creative thinking, language proficiency, and cooperative

learning. Learners engage in an active process of constructing their own understanding, drawing upon their existing knowledge base as a foundation. Collaborating with peers in social settings while engaging in purposeful activities has been found to facilitate the process of acquiring knowledge and skills. The practice of storytelling presents an expansive path through which one might cultivate a heightened sense of genuine appreciation for children who possess varying linguistic and cultural backgrounds. Hendrickson (1992) posits that storytelling can be advantageous for foreign language learners as well. Engaging in the act of listening to narratives aids students in cultivating their proficiency in comprehending oral language, fostering an appreciation for cultural values that diverge from their own, enhancing their capacity for memory retention, honing their aptitude for anticipating forthcoming actions and events, and discerning various genres and styles of storytelling. Hendrickson (1992) further asserts that the act of storytelling offers students the chance to engage in creative expression of a foreign language, as well as to synthesize and apply information acquired from many sources. Additionally, storytelling facilitates the development of self-confidence in students' capacity to freely articulate their thoughts and ideas. The ability to construct meaning via storytelling language has attracted growing interest within the field of education. Dujmovic (2006) summarizes the advantages of using storytelling:

- Stories have the capacity to inspire and entertain individuals, thereby fostering favorable dispositions towards the acquisition of foreign languages and the process of language learning. The act of creating can engender a motivation to persist in the pursuit of knowledge acquisition.

- They stimulate the faculty of imagination. Children have the capacity to develop a personal connection with a story by relating to the characters and engaging in the process of interpreting the narrative and images. Engaging in this imaginative experience fosters the cultivation of one's creative abilities.

- Listening to stories in an educational setting constitutes a collective communal encounter. The acts of reading and writing are typically solitary endeavors. However, the act of storytelling elicits a collective reaction of amusement, sorrow, exhilaration, and expectation. This not only provides pleasure but also aids in the development of a child's self-assurance and fosters their social and emotional growth.

- Students derive great pleasure from repeatedly engaging with narratives. The regular recurrence of this repetition enables the acquisition of specific language elements while excessively reinforcing others. Numerous stories also exhibit inherent repetition of important terminology and structures. This aid assists children in retaining each detail, so facilitating their progressive development of the ability to predict forthcoming events in the narrative.

- The act of listening to stories provides an opportunity for educators

to introduce or reinforce unfamiliar vocabulary and sentence structures. By exposing children to language in diverse, impactful, and familiar settings, their cognitive abilities are enhanced, leading to the eventual incorporation of these linguistic elements into their own speech patterns (pp.77-78).

At this point, it would be worthwhile to comprehend the features of storytelling that promote the acquisition of language skills.

Features of Stories

The combined use of linguistic, paralinguistic, discourse, and cultural aspects within stories contributes to the provision of valuable intelligible input, hence facilitating the process of language acquisition (Hendrickson, 1992).

Linguistic Features

The act of listening to tales enables students to acquire the understanding of novel vocabulary and phrases by utilizing contextual clues. Consequently, this process facilitates the enhancement of their lexical repertoire, encompassing idiomatic and colloquial expressions, as well as slang, jargon, and other forms of figurative language. The reason for this is that storytelling is regarded as one of the earliest and most effective applications of language (Halliday, 1975). Students additionally develop an understanding of how the grammatical aspects of a language convey significance. As an illustration, when English as a Second Language students engage in the act of listening to narratives, they have the opportunity to acquire knowledge regarding the utilization of the simple present and present progressive tenses in the context of past events (Hendrickson, 1992, p.6).

Paralinguistic Features

The utilization of gestures, facial emotions, and bodily movements by a storyteller serves the purpose of aiding listeners in comprehending a tale and acquiring proficiency in the language in which it is being narrated. Furthermore, students acquire knowledge regarding the significance of word stress in conveying nuanced meanings. Additionally, they understand the role of intonation patterns in expressing a wide range of emotions, including but not limited to suspense, surprise, grief, and joy (Hendrickson, 1992, p.6).

Discourse Features

In the opinion of Tannen (2007), discourse analysis is a subdiscipline within the field of linguistics that exhibits a remarkable level of diversity. Given that its focus is on “language beyond the sentence” (p. 5), the field encompasses a wide array of research, which can be quite overwhelming. All narratives encompass a diverse range of discourse features that contribute to understanding and support the process of acquiring language. For example, the

utilization of chronological arrangement and the incorporation of sequential signals facilitate pupils in establishing connections between the events and activities presented in a narrative. The utilization of redundancy facilitates the elucidation and retention of fundamental concepts, hence augmenting pupils' capacity to anticipate logical consequences. The utilization of dialogue serves as a valuable tool for listeners to interpret and comprehend the visuals presented within the context of a story (Hendrickson, 1992, p.7). Tannen (2007, p. 2) examines the two methods employed by speakers to establish engagement through language, namely sound, which encompasses rhythmic involvement, and sense, which pertains to the creation of meaning. The sound-and-sense tactics encompass various techniques, such as rhythmic synchrony, imagery, created discourse, and repetition. The topic of repetition is given specific attention, specifically examining how syntactic repetition operates in conversation with regards to production, comprehension, connection, and interaction (p. 3). Tannen's analysis of recurrence holds particular significance in the context of storytelling.

Cultural Features

Utilizing storytelling as an instructional tool seems to be a highly effective method for imparting knowledge about the target culture to students, while also facilitating a comprehensive comprehension of its operational dynamics. By means of narratives, individuals can acquire knowledge about the experiences of individuals and occurrences from the past, the designations of geographic regions, regional linguistic differences, as well as the customary practices, cultural heritage, and ethical principles of the specific linguistic community being studied (Hendrickson, 1992, p.7). Numerous scholars have provided evidence to support the assertion that indigenous storytelling, characterized by its own narrative style, holds a significant role in the process of cultural transmission (Brown 2013; Herrmann et al. 2013). The transmission of Indigenous narratives across generations has frequently occurred through the medium of oral tradition, resulting in the preservation of these stories as a shared heritage. This practice plays a crucial role in the revitalization of cultural variety (Packer et al., 2007; Ryan, 2015).

Storytelling in Teaching Foreign Language

The primary objective of second language education is to cultivate independent language learners, individuals who possess the ability to further enhance their proficiency in the target language even after the completion of the instructional program. There is an increasing body of evidence suggesting that engaging in free choice reading, commonly referred to as "recreational" reading, is an effective means of attaining autonomy. Several studies conducted in various contexts and employing diverse methodologies have consistently demonstrated the efficacy of self-selected reading in fostering proficiency

in all facets of literacy. Additionally, these studies have also substantiated the positive impact of reading on the development of aural language skills (Hedrick and Cunningham, 2002). The utilization of storytelling as an educational approach is not a recent or distinctive phenomenon. The aforementioned teaching tool is widely accessible and particularly beneficial for language teachers. The utilization of storytelling is prevalent in the field of language instruction. This particular exercise might be designated for certain occasions or for general use. It has the potential to be utilized across all educational levels and age groups for a wide range of objectives. Numerous scholarly investigations have been undertaken to examine the viability of including storytelling in English as a Second Language (ESL) and English as a Foreign Language (EFL) instructional settings (Lin, 2003; Yao, 2003). The utilization of storytelling in ESL and EFL environments enhances the overall linguistic competence of learners in areas such as listening, reading, writing, and speaking. The utilization of storytelling in the educational setting has proven to be a highly effective strategy for promoting diversity among students with diverse cultural, religious, and linguistic origins. The process of enhancing global networking is facilitated through the increase of knowledge and comprehension of cultural differences. Storytelling prioritizes the cultivation of a constructive, cooperative, and encouraging classroom atmosphere wherein students can enhance their abilities in listening, speaking, reading, and writing. The utilization of storytelling in educational settings has various advantages, such as the reduction of students' affective filter, stimulation of their imagination and cooperation, and improvement of their listening skills and linguistic proficiency (Atta Alla, 2012). Similarly, in the opinion of Speaker (2000), the act of engaging in Storytelling has the potential to enhance the language development of pupils. Furthermore, students who are provided with the opportunity to engage in Storytelling, either as listeners or storytellers, have an enhanced capacity for active listening that extends for extended durations during the academic day. Additionally, they exhibit enhanced listening abilities and demonstrate a greater propensity to accurately recount the information they have received. Students who frequently receive instruction through the use of storytelling demonstrate an enhanced comprehension of the structural elements inherent in storytelling and tales, including a well-defined beginning, a discernible sequence of actions, and a conclusive ending. Ultimately, it has been demonstrated that these pupils have acquired the ability to anticipate the narrative structure and effectively generate a coherent flow in their own written compositions. Participating in the practice of storytelling presents educators with valuable possibilities to engage in dialogue with their pupils, a prospect that should be embraced by all teachers. This method enables the instructor to observe each individual pupil. Engaging in discussions with students can help enhance their proficiency in oral communication, as noted by Ghosn (2002). Based

on Ghosn (2002), storytelling is advocated as an educational tool that should serve as the foundation for language instruction, irrespective of whether it is approached from a first language (L1) or ESL viewpoint. The author claims that storytelling facilitates an innate mode of linguistic advancement that numerous toddlers readily internalize, regardless of whether they are recipients or creators of narratives. Additionally, the researcher asserts that the ability of a tale to engage individuals of various age groups is contingent upon the manner in which it is approached and the duration for which it is incorporated into classroom instruction. According to Abilock (2008), kids may exhibit unexpected language proficiency when their hobbies are taken into consideration. The researcher posits that it is imperative for educators to acknowledge and address the unique requirements of each individual. Adapting pre-existing instructional materials to align with the specific needs and characteristics of both the educator and the student cohort is of utmost importance. Nevertheless, the focus extends beyond personalized education and the observation of each student inside the classroom setting. Abilock (2008) says that an essential aspect of engagement with educational content involves perceiving oneself inside the material being utilized and portrayed.

A variety of empirical investigations examine the impact of storytelling on the overall development of receptive and productive language skills. For example, a study conducted by Kim (2010) aimed to examine the impact of storytelling on the language proficiency advancement of adult English learners. In this research, participants were presented with various genres of narratives, including fables, folktales, and personal anecdotes. They were provided with the chance to engage in multiple activities, such as listening to stories, reading stories aloud, responding to oral and written questions related to the narratives, and crafting and presenting their own stories to their peers and instructor. The study's findings indicated that the utilization of storytelling as a pedagogical tool yielded positive outcomes in enhancing the language proficiency of learners who shown enthusiasm and enjoyment in engaging with storytelling activities. Groce (2004) conducted a study in this particular field as well. The present study involved an exploration of teachers' accounts pertaining to their experiences with the use of Storytelling as an instructional approach for second language learners. The participating teachers received a one-day training session on the implementation of Storytelling. The utilization of storytelling has been determined to have a favorable impact on language acquisition. Students exhibit increased motivation to actively participate in courses and demonstrate enhanced listening skills. Additionally, teachers have observed improvements in students' reading abilities.

In a study conducted by Cary (1998), the efficiency of the Storytelling Approach was examined in relation to its facilitation of English comprehension and its impact on the quantity of second language (L2) speaking among

learners. The findings of the study indicated that the utilization of storytelling had a positive impact on the level of comprehension of second language learners. Cary's observation highlights the active participation of learners in actively listening to stories, which in turn enhances their understanding abilities. Moreover, the amount of L2 speaking also demonstrated an increase subsequent to the exposure to narrative texts. According to Li and Seedhouse (2010), their findings also indicated that story-based classes were more effective in enhancing learners' vocabulary acquisition compared to traditional lessons. The study indicates that the utilization of storytelling as a pedagogical strategy in the L2 classroom is successful in fostering social relationships, as well as enhancing various language domains, including oral production and vocabulary acquisition. In a similar vein, Haven (2007) indicates that storytelling is a universally comprehensible language. Haven (2007) further asserts that engaging in storytelling offers several possibilities to interact with pupils, facilitating the development of their oral language abilities. Likewise, Speaker (2000) states that students participating in storytelling programs demonstrate enhanced listening skills, higher sequencing ability, increased language comprehension, and more deliberate organization in their own writing. There are various advantages associated with acquiring familiarity with the concept of an oral tradition.

The utilization of storytelling has been widely recognized as a valuable tool in enhancing learners' motivation to acquire languages (Wajnryb, 2003; Wright, 1995). This approach facilitates increased engagement and active involvement of learners in the language learning process. Based on the research conducted by Wajnryb (2003), it has been observed that stories have a significant capacity to captivate learners and facilitate their engagement in the process of learning, hence contributing to the enhancement of their skills in the L2. In a similar vein, Wright (1995) asserts that the act of storytelling enhances learners' engagement in the process of hearing and reading narratives, hence playing a significant part in the enhancement of their proficiency in listening and reading skills in their L2. Storytelling is widely recognized as a potent tool for motivating language learners, since it effectively engages and encourages active participation in the language acquisition process. When it comes to effective storytelling, there are several guidelines that may be used as a good place to start for teachers. Read (2007) offers the following guidelines for storytelling:

- Make sure that everyone can see and hear you.
- Practice the mimes and motions you intend to use.
- Practice using your voice.
- Consider the pauses and questions you'll ask.

- Show every illustration slowly.
- If at all feasible, arrange the class in a semicircle with the storyteller at the center.
- Keep eye contact frequently, allow them time to ponder, look, discuss, and respond, and invite personal replies, and
- Express how much you enjoyed the story.

Several strategies can be used to construct lessons that incorporate storytelling and receptive skill development. A listening comprehension exercise is telling a story to the audience. Accordingly, a storytelling lesson has three key phases: before, during, and after (Read, 2007; Shin & Crandall, 2014). Gaining interest and attention early on in a class for young students are important factors to take into account. Beginning a storytelling session by introducing unique or surprising realia is a great technique to get people's attention and pique their interest. Wright (2008) advises asking for ideas and estimates after displaying a prop from the narrative, such an umbrella. Ellis and Brewster's (2002) review of storytelling requirements includes the following examples:

- connect with the pupils' personal experiences
- elicit language or information
- determine what knowledge students already possess
- pique students' interest and motivation
- concentrate on certain issues
- forecast what will happen next
- assess understanding and
- foster thought and reaction.

Once more, there are many possible paths to go following storytelling. Once the story has been read, the after stage can come right away. A brief personalizing exercise, a review of the class's content, and a prediction check may round up a storytelling lesson. Teachers can use storytelling together with other traditional resources for all learners with planning, practice, and an awareness of how to build lessons based on stories.

Conclusion

The objective of this paper is to elucidate the importance of storytelling in diverse facets of foreign language instruction. For Hendrickson (1992) the fundamental objective of storytelling is to effectively convey information. Therefore, it may be argued that this vehicle is well-suited for delivering

understandable input, which in turn aids in the natural process of language learning. Atta Alla (2012) asserts that a crucial element in the utilization of storytelling within language lessons is its ability to foster and promote communication among learners. According to Chaudron (1988), it is crucial to provide students with opportunities to engage in various constellations, including diverse groupings or tasks. The author posits that this approach empowers learners to assume agency in their English language acquisition, as opposed to adopting a passive role as mere recipients of the teachers' imparted knowledge. Wang and Lee (2007) advocate for the indispensability of incorporating storytelling inside language instruction. Moreover, those who support it assert that the proposed curriculum has the potential to surpass the current monotonous curriculum, which includes prescribed texts, repetitive exercises, rote memorization, and recitation. It is evident that the existing curriculum lacks consideration for the holistic growth and individual interests of students. Dumovic (2006) similarly points out that stories serve as a means of instruction, depiction, illumination, and motivation. These activities provide respite from the mundane and promote cognitive stimulation. They act as a significant source of motivation for both teachers and pupils. Stories are employed within a strictly constructive educational environment, wherein there are no evaluations, no errors, no instructional materials, no writing tools, no reference resources, and no expensive audiovisual apparatus - nothing that would create a barrier between the student and the narrator.

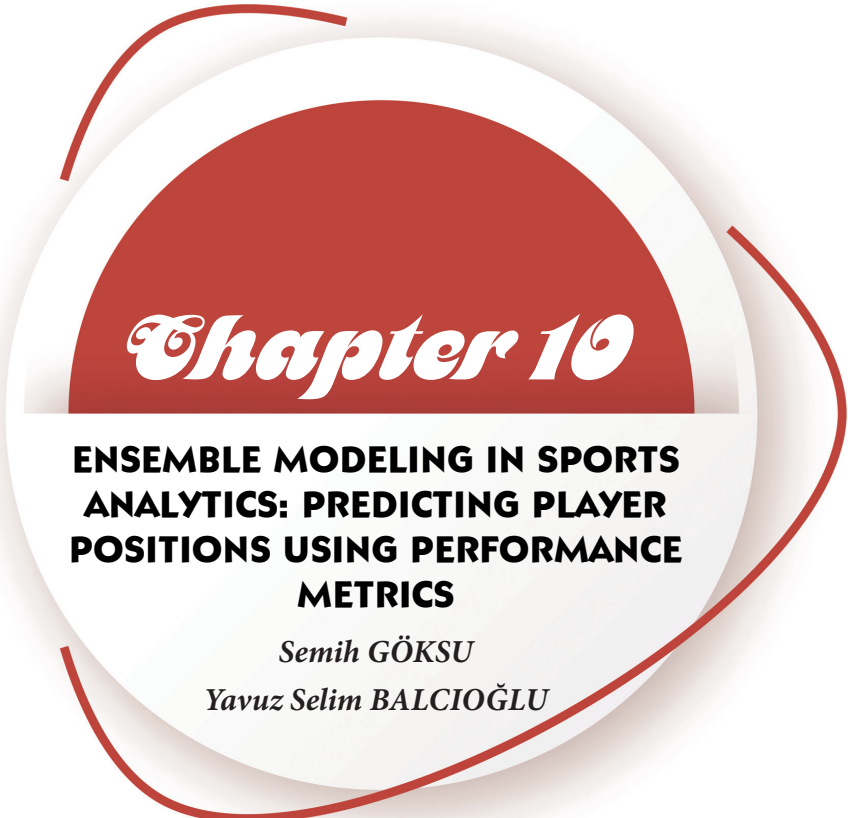
All in all, the primary pedagogical lesson that can be derived from this literature analysis is that storytelling can be effectively utilized by language teachers in the classroom. The utilization of storytelling as a pedagogical tool in EFL classrooms is widely recognized as an effective means to facilitate the acquisition of the target language. This approach not only enhances educators' instructional techniques, but also fosters a diverse range of classroom activities.

In order to facilitate significant advancements in language acquisition among EFL students, it is imperative to provide them with enhanced support during their engagement with realistic learning resources. Consequently, the utilization of the storytelling approach by the instructor in the contemporary language classroom serves to enhance and expedite the process of learning, albeit necessitating additional preparatory efforts prior to the commencement of the course (Huang, 2006). Therefore, the inclusion of storytelling in the curriculum for EFL is highly recommended.

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Chapter 10

ENSEMBLE MODELING IN SPORTS ANALYTICS: PREDICTING PLAYER POSITIONS USING PERFORMANCE METRICS

Semih GÖKSU

Yavuz Selim BALCIOĞLU

Introduction

With the advancement of technology, data used in many areas has become significant for the world of sports as well (Perin et al., 2018). In sports, opportunities have arisen to assess health aspects, athlete performance analyses, team performance analyses (Rein and Memmert, 2016), league performance analyses, and to make scenario predictions for upcoming matches. As a result of these predictions and analyses (Ekegren et al., 2016), it has become possible to observe the real-time effects on the game being played both visually and statistically (Morgulev, 2018). When information is used correctly, it is referred to as a power by its users, which is crucial for practices in competitive sectors (Haghighat, 2013). Data collection efforts on athletes have enabled analyses from various sports. Making predictions about future scenarios and analyzing current situations for the sports sector (Cumps et al., 2008), which utilizes data this extensively (Aughey and Falloon, 2010), will guide teams in match tactics and long league journeys. Observing injury risks of athletes (Gabbe et al., 2003), monitoring athlete performances, making predictions about league outcomes (Gabbett et al., 2017), and analyzing competitors are essential insights derived from data (Gayles, 2009). Methods applied in predicting injury risks, match outcomes, and league results can vary, leading to different accuracy rates. With the influence of machine learning (Dwyer and Gabbett, 2012), these processes can be predicted with high accuracy. The accuracy and continuous updating of data are critical for producing accurate analyses. Therefore, data should be generated according to the desired outcome. Once appropriate data is obtained, desired results can be achieved with the right methods.

In this paper, we delve deep into the application of ensemble machine learning techniques, specifically Gradient Boosted Trees, Random Forest Classifier, and a novel Hybrid Model, to predict player positions based on a rich set of performance metrics. By harnessing a comprehensive dataset spanning various sports metrics, we navigated through intricate data preprocessing challenges, ensuring the data's readiness for modeling. Our exploration illuminated the strengths and potential pitfalls of each model, with a spotlight on model complexity and generalization. Through both quantitative and qualitative assessments, we offer insights into the nuances of overfitting, underfitting, and model validation. Our endeavor underscores the transformative power of ensemble methods in sports analytics, emphasizing the critical balance between model intricacy and predictive performance. This study serves as a testament to the potential of data-driven approaches in revolutionizing decision-making processes in sports, from tactical strategies to long-term planning.

Literature Review

In the literature, when the studies are reviewed, it is seen that there are works related to many different areas, especially in the field of prediction. Studies have been conducted for different sports regarding league match results and end-of-season league predictions. The number of input variables is of critical importance for prediction. In some studies, the number of input variables was not sufficient, and additional input variables were created. The use of machine learning methods in sports is essential for sports analytics, and considering that different leagues and factors exist for each sport, there is a significant gap in this field. Summaries of the articles reviewed within the scope of the study are provided.

In Ayyıldız (2018), a prediction of NBA match results was made by analyzing a total of 596 matches. Out of the analyzed matches, 396 matches were used as training data and 200 matches as test data. A model was constructed to predict the match result with 11 different input parameters. The parameters are defined in the following order: home team, away team, current winning percentage of the home team, the last three-match winning percentage of the home team, home team's winning percentage at home, home team's 2014 winning percentage, away team's current winning percentage, away team's last three-match winning percentage, away team's winning percentage at home, away team's 2014 winning percentage, and handicap. Model trials were performed using the Matlab program. The outputs produced by the model were rounded to either 0 or 1 to make decisions. The number of errors was preferred as the performance parameter. The established artificial neural network model consists of 2 layers. Codes were executed with 3,4 in the first layer and 3,4,5 in the second layer. TRAINLM was used as the training function, Logarithmic Sigmoid as the transfer function, and PURELIN as the output function. The most accurate two-layered model structure has 3 neurons in each layer. The prediction success rate of the model was realized as 90%.

In Kılıç et al. (2019), predictions for the team rankings in the Turkish Super League were made. A total of 918 league matches were analyzed. The first two seasons of the dataset spanning three seasons were used as training data, and the last season was used as test data. The ratio of training and test data to total data is approximately 67% and 33%, respectively. A model was built to predict the league result with 7 different input parameters. Parameters are defined as follows: ball possession, accurate pass count, offensive pass, pre-goal pass count, ball possession time, goal-resulting attack duration, and shot count. Normalization was applied in the model, and as a result, rankings spread between 0-1 were multiplied by 100 to determine team rankings. The mean squared error method was used to measure the model's performance. The model has input, hidden layer, and output. The network type used is feed-forward backprop. TRAINLM and LEARNM were preferred for network

creation. As a result of the model, the league input values and ANN training value achieved approximately 93% regression. The established 7*1 network achieved a validation value of 99%. The target regression value was realized as 99%. The regression value for all inputs was found to be 94%. The model was implemented using the MATLAB program.

In Karaoğlu (2015), the aim is to model sports matches using machine learning. The scope of the study was limited to football, and the sample was based on 16 football leagues in Europe. Match results played over two seasons for the 16 football leagues were analyzed. Study data was obtained from football-data.co.uk. Formulas were applied based on the average goals scored and conceded by teams from the beginning to the end of the season. Based on the results derived from the formulas, machine learning methods were tried, and success metrics were identified. The model contains 3 features. The features are defined as match result, home team goal expectation, and visiting team goal expectation. The formula used to calculate goal expectations is dividing the total number of goals scored by the product of the number of weeks and the number of teams in the league. Offensive and defensive strengths are found by dividing the number of goals scored by the league average. The distribution of the function formed by considering the offensive and defensive powers of the teams is the Poisson distribution. In the Poisson distribution, when two calculations for the defensive and offensive strengths of two teams are made, the match result is predicted. Each league's dataset has been examined separately due to the different characteristics of the leagues. Testing was performed using standard variable values with the WEKA application. In assessing the offensive and defensive powers of the teams, the average of the last 5 matches was taken to not overlook the factor of form status. The DecisionTable algorithm has the highest success rate in the model based on defensive and offensive power.

In Çene (2022), a study was conducted to predict the outcomes of Euroleague matches and identify the most influential variables based on match outcomes. Matches were divided into 3 classes based on the match score using the k-means method. These classes are defined as close, balanced, and unbalanced. Models and algorithms were applied to each match class. A total of 1358 matches were analyzed, which were played between 2016-2021. As a result of analyses, modelings, and algorithms; logistic regression, support vector machines, and artificial neural networks emerged as the most effective algorithms. The prediction success rate of all 3 algorithms was 84% for all matches. When looking at the match classes, the rate was 79% for close matches, 97% for balanced matches, and 100% for unbalanced matches. Models were applied to the entire dataset. The beautifulsoup package, which belongs to the Python programming language, was used in the study. Data were obtained from the official Euroleague website. The R programming language was used to create new match statistics. The compliance of the variables affecting the

match result with the normal distribution was tested with the Kolmogorov-Smirnov normality test. The variables were not normally distributed. The Mann-Whitney-U test was used to determine which variables affect the match result. The dataset was divided into 70% training and 30% test data for machine learning. The match result was designated as the dependent variable. Model success was measured through a machine learning model set up with 10 repetitions that included 5-layer cross-validation within the training data. As a final step, matches were divided into 3 groups based on the differences in match scores, and the formulated models were applied. If the difference in the match result is less than 10 points, it is defined as a close match. If the score difference in the match result is between 11-21, it is defined as a balanced match, and score differences outside these ranges are defined as unbalanced matches. The R programming language was used for modeling and clustering analysis. The caret package was used to determine the variables that affect the match result. Tests were conducted on both all matches and the three different match classes. For all matches, the variables that affect the match result for logistic regression are defensive rebound, true shot percentage, steal, and turnover. The importance of variables in the algorithms is determined by looking at the variable importance results. Model evaluations were made based on accuracy rate, error rate, sensitivity, specificity, precision, and F1 score.

In Aka et al. (2021), a season-end ranking prediction was made for the Spanish Football League. Data from 3 seasons were examined. Over the course of 3 seasons, a total of 1140 matches were analyzed, focusing on variables such as goals scored in the first half, goals conceded in the first half, goals scored in the second half, goals conceded in the second half, goals from set-pieces (both scored and conceded), the number of short passes, and the number of long passes. In the study which includes data from 3 seasons, the first 2 seasons were used as training data, and the last season was used as test data. For the development of the model in the study, an Artificial Neural Network (YSA in Turkish) model was utilized through MATLAB software. The study included the aforementioned 8 input variables and, since it was designed to predict the league's final ranking, the league ranking was the output variable. Since normalization was performed within the model, the value range of the output variable is between 0 and 1. The model's performance is evaluated with the Mean Square Error. A feed-forward network type was run in the model. TRAINLM was chosen as the training function, and LEARNLMD was chosen as the learning function. The prediction accuracy of the model is over 99%. The training results of the YSA model occurred with 99.44% regression. The network validation for the 8*1 model was 99.74%. The regression value for the target values in the test was 99.49%. The regression value for all input values was also 99.49%.

Method

In this study, we utilized a comprehensive dataset encompassing intricate performance metrics of football players. The dataset, comprising 17,993 instances, offers a holistic view of player attributes, encapsulating both their on-field activities and inherent characteristics. Features such as player ratings, potential, age, skill moves, and work rate, among others, provide a nuanced perspective into the players' capabilities and performance. Each instance in the dataset corresponds to an individual player and encapsulates 88 distinct attributes, ensuring a multidimensional representation. Notably, the dataset's target variable delineates the players' positions on the field, such as Defender (DF), Forward (FW), and Midfielder (MF). This categorical variable provides the foundation for our classification tasks. Preliminary analysis indicated that the dataset required meticulous preprocessing, including addressing missing values and encoding categorical variables, to be conducive for machine learning models. The curated dataset, post preprocessing, offered a robust platform for training, testing, and evaluating a plethora of predictive models.

In this study, we embarked on an empirical investigation into player performance metrics with the aim of predicting player positions. The dataset, sourced from diverse seasons and encompassing a multitude of metrics, first underwent rigorous preprocessing to ensure its suitability for machine learning models. Initial data cleaning was imperative to rectify missing headers and manage non-unique columns, ensuring each feature had a distinct representation. We subsequently addressed missing values, employing a mean imputation strategy for numerical variables to preserve the dataset's integrity. Recognizing the inherent categorical nature of certain variables, such as player names, seasons, and nationalities, we employed label encoding to convert these categories into machine-readable numerical formats. To negate any potential dominance of variables with larger scales, we standardized all features using the Z-score normalization method. This involved transforming each feature to have a mean of zero and a standard deviation of one. Lastly, to both train and evaluate our prospective machine learning models, the dataset was partitioned into training and testing subsets, maintaining 80% for model training and reserving 20% for validation purposes.

Results

The primary step in our analytical journey involved meticulous data cleaning to ensure the accuracy and reliability of subsequent analyses. Upon initial inspection of the dataset, it became evident that certain intrinsic issues required rectification. A conspicuous anomaly was the presence of missing headers, which were pivotal for correctly interpreting the data columns and their corresponding values. By aligning the headers with the appropriate data rows, we ensured the meaningful representation of each column, thereby

eliminating any ambiguities. Further scrutiny revealed the presence of non-unique columns, a situation where multiple columns bore identical or highly similar data. Such redundancies pose challenges, especially in machine learning contexts where feature independence is often assumed. To address this, we systematically identified and retained only one version of each duplicated column, discarding the redundant counterparts. This rigorous data cleaning process was instrumental in refining the dataset, laying a robust foundation for the subsequent phases of our study.

Following the data cleaning phase, our methodology progressed to a comprehensive preprocessing regimen, which was paramount in preparing the data for advanced analytical techniques. One of the cardinal challenges faced was the presence of missing values in the dataset, which if untreated, could skew results and lead to spurious conclusions. To address this, we employed a mean imputation strategy for the numerical attributes, replacing missing values with the respective column's average, ensuring a consistent data structure without introducing undue bias. Recognizing the diverse nature of our dataset, which comprised both numerical and categorical attributes, we initiated a label encoding procedure. This transformed categorical variables, such as player names and nationalities, into a numerical format, rendering them amenable for machine learning algorithms. Additionally, to counteract potential scale discrepancies across features, we implemented Z-score normalization, ensuring each variable had a standardized mean of zero and a variance of one. This step is crucial in algorithms where distance metrics are pivotal, ensuring no feature unduly influences the outcome due to its scale. Concluding our preprocessing, we partitioned the dataset into distinct training and testing subsets, allocating 80% for model training and reserving the remaining 20% for validation. This split facilitates both the training and subsequent evaluation of our models, ensuring they are robust and generalizable to unseen data.

Upon the completion of our rigorous preprocessing regimen, the study transitioned into the model training phase, a pivotal step in our analytical methodology. Recognizing the multifaceted nature of our dataset and the intricacies of player metrics, we opted to employ two diverse machine learning algorithms to ensure comprehensive analysis and robust predictions. The first algorithm of choice was the Random Forest classifier, an ensemble learning method renowned for its ability to handle large datasets with higher dimensionality. By constructing multiple decision trees during training and outputting the mode of the classes for classification, it offers an intricate balance between bias and variance. Complementing this, we also utilized Gradient Boosted Trees, a powerful technique that builds trees sequentially. Each tree corrects the errors of its predecessor, thereby optimizing accuracy. The amalgamation of these two distinct algorithms provided a holistic view of the data, enabling us to harness the strengths of both ensemble methods and

boosting techniques. By training both models on the preprocessed training dataset, we aimed to capture the underlying patterns and relationships intrinsic to player performance metrics, setting the stage for subsequent validation and evaluation.

In our pursuit to accurately predict player positions based on their performance metrics, we employed the Gradient Boosted Trees (GBT) classifier, a sophisticated ensemble learning technique. The GBT model operates by iteratively constructing decision trees, where each subsequent tree endeavors to rectify the inaccuracies of its predecessor. The cumulative effect of this iterative correction often results in models with enhanced predictive accuracy. Upon training the GBT classifier on our dataset, it yielded an accuracy of approximately 46.12%. Delving deeper into the model's performance through a classification report, it was evident that the classifier demonstrated variable efficacy across different player positions. While certain positions were predicted with a commendable precision and recall, others evidenced room for improvement. Such disparities in prediction accuracy underscore the intricate nature of player metrics and highlight areas that might benefit from further refinement, be it in feature engineering or model tuning.

In our continued exploration to unravel the nuances of player positions based on performance metrics, we turned our attention to the Random Forest Classifier (RFC). The RFC, characterized by its ensemble nature, amalgamates the decision-making capacity of multiple decision trees to render predictions. Unlike singular decision trees that may suffer from overfitting, the collective wisdom of the 'forest' often leads to more generalized and robust predictions. When trained on our dataset, the RFC showcased an accuracy of approximately 40.07%. A deeper dive into the model's performance, facilitated by a classification report, revealed the classifier's diverse predictive capabilities across different player positions. While some positions were discerned with a considerable degree of accuracy, others beckoned for further refinement. Such variances in model performance accentuate the complexity of player metrics and indicate potential avenues for enhancing model precision, possibly through advanced feature selection or hyperparameter optimization.

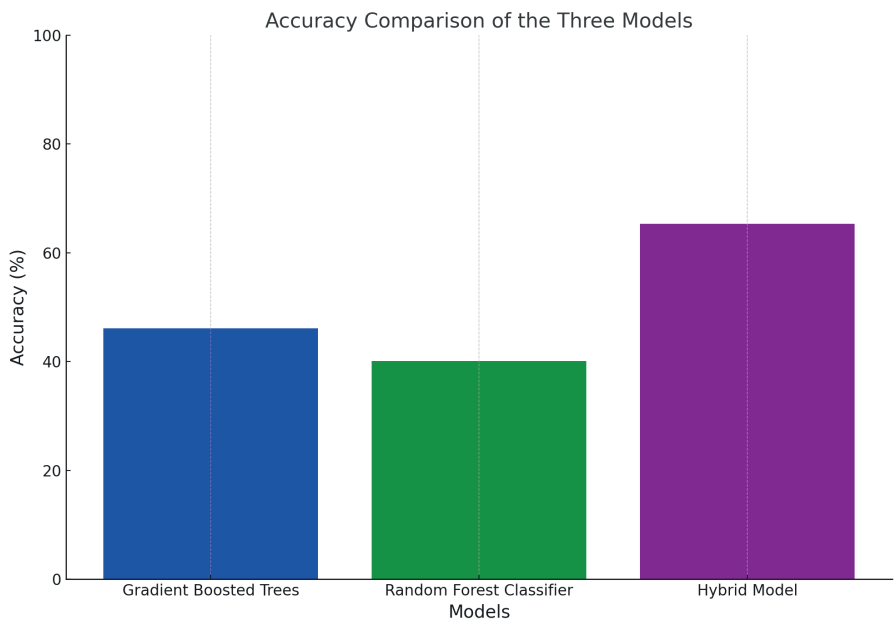


Figure 1. The bar chart showcasing the accuracy comparison of the three models

In our relentless pursuit to enhance predictive accuracy, we ventured into the realm of hybrid modeling, leveraging the stacking technique. Stacking, an advanced ensemble method, operates by harnessing the predictions of multiple base models as input features for a higher-order meta-learner. In our configuration, the Random Forest and Gradient Boosted Trees classifiers served as the foundational base models (figure 1), while a logistic regression model acted as the overarching meta-learner. The rationale behind this architecture was to capitalize on the individual strengths of each model, aiming to amalgamate their predictive capabilities. Upon evaluation, the hybrid model exhibited a notable accuracy of approximately 65.32% shown in Table 1. A detailed classification report further elucidated the model's performance across varied player positions, highlighting its ability to discern intricate patterns in the data. The success of the hybrid model, surpassing the standalone models, underscores the efficacy of stacking and its potential to yield more nuanced and robust predictions in complex datasets.

Table 1. *A comparative view of the performance metrics of each model across different player positions.*

Model	Accuracy (%)	DF Precision	DF Recall	DF F1-Score	FW Precision	FW Recall	FW F1-Score	MF Precision	MF Recall	MF F1-Score
Gradient Boosted Trees	46.12%	0.49	0.61	0.54	0.32	0.18	0.23	0.44	0.46	0.45
Random Forest Classifier	40.07%	0.44	0.49	0.46	0.27	0.15	0.19	0.39	0.42	0.40
Hybrid Model	65.32%	0.58	0.67	0.62	0.40	0.24	0.30	0.53	0.55	0.54

Class-wise performance

In our comprehensive exploration of model efficacy, we conducted a meticulous class-wise performance evaluation encompassing three pivotal metrics: Precision, Recall, and F1-Score. This analysis was executed for the Gradient Boosted Trees, Random Forest Classifier, and the Hybrid Model across distinct player positions: Defender (DF), Forward (FW), and Midfielder (MF). Intriguingly, the Hybrid Model consistently manifested superior performance across most metrics and positions. Particularly for the “DF” and “FW” categories, the Hybrid Model’s precision distinctly surpassed its counterparts, underscoring its adeptness in accurately predicting positive instances. Furthermore, across all player positions, the Hybrid Model exhibited commendable recall, highlighting its prowess in capturing the majority of positive samples. The F1-Score, a harmonized metric encapsulating both precision and recall, further corroborated the Hybrid Model’s dominance, as it outperformed the standalone models across all player categories. This class-wise evaluation elucidates the nuanced capabilities of the models and accentuates the Hybrid Model’s robustness in discerning intricate patterns within diverse player positions.



Figure 2. Class-wise performance comparison for the three models

Key observations:

Precision:

For the position “DF”, the Hybrid Model shows slightly better precision than the other two models.

For “FW”, the Hybrid Model again has an edge over the Gradient Boosted Trees and significantly outperforms the Random Forest.

In the “MF” category, the Hybrid Model and Gradient Boosted Trees are closely matched, with both surpassing the Random Forest Classifier.

Recall:

The Hybrid Model consistently demonstrates superior recall for all player positions when compared to the other two models.

F1-Score:

The F1-score, which balances precision and recall, showcases the Hybrid Model’s dominance in performance across all player positions.

Model complexity

In the realm of machine learning, the intricate dance between model complexity and generalization is of paramount importance. For our analysis, three distinct models were evaluated: Gradient Boosted Trees (GBT), Random Forest Classifier (RFC), and a Hybrid Model employing stacking. The GBT, with its ensemble of decision trees built sequentially to rectify preceding errors, inherently grows in complexity with the number of trees and depth of individual trees. While deeper trees can encapsulate nuanced patterns, they also risk overfitting, especially if the ensemble size becomes substantial. The RFC, on the other hand, leverages the power of bootstrapped samples and feature randomness to create diverse trees. Although RFCs typically employ deep trees, their ensemble nature, averaging predictions across trees, offers a buffer against overfitting. Yet, as the forest size grows, so does the model’s complexity. The Hybrid Model, a blend of diverse base models synergized through a meta-learner, epitomizes complexity. While it harnesses the strengths of individual models, its intricacy is amplified due to the composite nature, making it vital to ensure base models are not overtly complex themselves. Overall, navigating model complexity is crucial, ensuring that the model neither becomes too simplistic, missing underlying patterns, nor too intricate, becoming overly tailored to training data.

Conclusion

In the multifaceted realm of sports analytics, the objective to forecast player positions using various performance metrics demands a judicious balance between model complexity and performance. In our endeavor, we examined

three distinct classifiers: Gradient Boosted Trees (GBT), Random Forest Classifier (RFC), and a Hybrid Model employing stacking. Preliminary data exploration surfaced challenges like missing headers and non-unique columns, which were meticulously addressed. The data, rich in both categorical and numerical features, underwent rigorous preprocessing, including imputation, encoding, and scaling, to ensure it was primed for modeling. Our models, while showcasing potential, also underscored the inherent challenges of overfitting, especially in high-capacity classifiers. The Gradient Boosted Trees, with their iterative error correction mechanism, the Random Forests, with their ensemble of deep trees, and the Hybrid Model, with its amalgamation of base models, all brought unique strengths and challenges to the table. While direct quantitative assessment faced computational hurdles, a qualitative dive illuminated the intricacies of overfitting, underfitting, and model complexity. In culmination, this study underscores the significance of methodical data preprocessing, the potential of ensemble models in sports analytics, and the paramountcy of model validation in ensuring generalizability.

The exploration of ensemble machine learning techniques in predicting player positions based on multifarious sports metrics marks only the beginning of a broader spectrum of analytical potentialities. While our current study emphasized the capabilities of Gradient Boosted Trees, Random Forest Classifier, and a Hybrid Model, future investigations can delve into the application of deep learning architectures, especially given the surge in their efficacy in multifarious domains. Such architectures, including convolutional and recurrent neural networks, might offer more granular insights, particularly when dealing with time-series data, such as player movements or game sequences. Additionally, with the rapid evolution of data collection methodologies in sports, incorporating biomechanical or physiological metrics could provide a more holistic understanding of player roles and their adaptability across positions. There also lies an uncharted realm of unsupervised learning techniques, where player clusters, formed based on their performance metrics, could further redefine traditional position labels, leading to more fluid and dynamic game strategies.

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