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PRESENTACIÓN

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A quasi-experimental study on the effectiveness of augmented reality technology on english vocabulary learning among early childhood pupils with learning disabilities

Un estudio cuasi-experimental sobre la efectividad de la tecnología de realidad aumentada en el aprendizaje del vocabulario inglés entre alumnos de educación infantil con discapacidades de aprendizaje

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ABSTRACT

This study addresses a gap in research by aiming to investigate the efficacy of augmented reality technology on vocabulary development for early EFL childhood pupils diagnosed with learning disabilities—a demographic known for significant learning challenges. A quasi-experimental design involving 30 pupils split into experimental and control groups was employed. The experimental group was taught using AR technology, while the control group received conventional instruction. Over a three-month period, both groups were assessed using a pre and post-test designed to measure vocabulary skills: recognition, recall, guessing, and production. Results revealed that the experimental group, exposed to augmented reality, outperformed the control group in all four vocabulary learning skills. This enhancement can be attributed to augmented reality's ability to engage the pupils' visual, aural, and kinesthetic senses, making learning more immersive and interactive.

KEYWORDS Augmented reality technology; EFL; early childhood; learning disabilities; vocabulary learning.

RESUMEN

Este estudio aborda una laguna en la investigación al proponerse investigar la eficacia de la tecnología de realidad aumentada en el desarrollo del vocabulario para alumnos de educación infantil EFL diagnosticados con discapacidades de aprendizaje, un grupo demográfico conocido por enfrentar significativos desafíos en el aprendizaje. Se empleó un diseño

cuasi-experimental con 30 alumnos divididos en grupos experimentales y de control. Al grupo experimental se le enseñó utilizando tecnología de RA, mientras que el grupo de control recibió instrucción convencional. Durante un período de tres meses, ambos grupos fueron evaluados mediante una preprueba y una prueba posterior diseñadas para medir habilidades de vocabulario: reconocimiento, evocación, conjetura y producción. Los resultados revelaron que el grupo experimental, expuesto a la realidad aumentada, superó al grupo de control en las cuatro habilidades de aprendizaje del vocabulario. Este mejoramiento puede atribuirse a la capacidad de la realidad aumentada para involucrar los sentidos visuales, auditivos y kinestésicos de los alumnos, haciendo que el aprendizaje sea más inmersivo e interactivo.

PALABRAS CLAVE Tecnología de realidad aumentada; ILE (Inglés como Lengua Extranjera); educación infantil; discapacidades de aprendizaje; aprendizaje de vocabulario.

1. INTRODUCTION

Improving one's vocabulary in a foreign language is essential for language growth and learning. Teachers cannot frequently build effective vocabulary training programs because they strive to make classes entertaining and successful (Al-khresheh et al., 2022). According to researchers and educators working with first and second languages, a rich vocabulary is essential for linguistic maturity. Although acquiring a second language's vocabulary is comparable to learning the vocabulary of a first language, the two expand at varying times. Connecting with others through a common language has become increasingly important. A sizeable vocabulary is an essential component of one's level of language ability and is required for effective communication. A connection is made between the four different language skills through vocabulary (Sadikin & Martyani, 2020). Vocabulary is crucial for the development of the student's literacy skills. The direct teaching of a term, however, has been shown to aid vocabulary learning in children with developmental language impairment, Down syndrome, autism, and reading difficulties, according to several studies (Al-khresheh, 2020; Al-khresheh & Al-Qadri, 2021; Colenbrander et al., 2019; Kouvava, et al., 2022;). Notably, early childhood pupils with learning disabilities have difficulty building their vocabularies and remembering the terminology they have just been taught (Booton et al., 2021; Willoughby et al., 2017).

Early intervention is regarded as essential for young children's intellectual and emotional development, which influences the students' cognitive performance and academic achievement later on. Pupils with learning disabilities with recurrent failures in early childhood education probably suffer in later educational stages, particularly in intellectual capabilities. This is because of the nature of their learning problems. Therefore, researchers need to work on finding, testing and spreading ideas and strategies that support the cognitive and academic learning needs of students with learning disabilities (Al-Qadri et al., 2021; Balikci & Melekoglu, 2020; Kennedy et al., 2015).

Many researchers look at numerous elements that may help in learning English, considering vocabulary is essential to learning the language (Adlof et al., 2021; Ali, 2020; Mohamed, 2021). Furthermore, many scholars and English teachers are attempting to develop various multimedia techniques to enhance students' vocabulary development (Busra et al., 2021; Oh, 2020; Wang & Lee, 2021). Early childhood special education instructors now have various tools for teaching language to young pupils with learning disabilities. One of

today's contemporary technologies that can fulfil this function is augmented reality (AR) technology. It can merge real images with virtual ones (Alkhattabi, 2017; Buchner & Kerres, 2023; Eldokhny & Drwish, 2021).

Incorporating AR technology in educating children with learning disabilities is essential. These pupils thrive in engaging and interactive learning environments, and AR apps have the potential to revolutionize their educational experience. By offering tailored support and interactive experiences, AR technology can significantly aid these young learners in language development, making the learning process enjoyable and effective. Chen and Chan (2019) and Sun et al. (2019) noted that well-designed AR applications can assist children with special needs, enhancing their language learning journey. The potential impact of this technology on their educational outcomes makes this an area of critical importance and great potential in special education. Therefore, this study aims to investigate AR technology's efficacy on vocabulary development in early EFL children with learning disabilities. This study makes a significant contribution to the existing body of research by documenting important information on the use of AR applications in assisting early childhood children who have learning disabilities to improve their vocabulary learning by answering the following question:

- What impact does AR technology have on the vocabulary learning process in early childhood pupils with learning disabilities?

In response to the posed research question, the study advances the following hypothesis: Vocabulary development in early childhood pupils with learning disabilities is significantly influenced when instruction is administered through AR technology, as opposed to conventional teaching methodologies.

2. LITERATURE REVIEW

2.1. Understanding Learning Disabilities: Language Barriers and Beyond

Learning disabilities, in their different manifestations, present various problems that pervade various aspects of educational endeavours (O'Connor et al., 2019). These disorders can be neurological, causing issues with information processing, reading, writing, reasoning, or even mathematical abilities (Peterson et al., 2021). Language competency becomes complex for learners navigating this terrain (Brown, 2015). According to Bao (2023), vocabulary emerges as a fundamental and often difficult pillar in this elaborate tapestry of language learning.

For pupils with learning disabilities, navigating the linguistic journey is far more complex than their typical peers, mainly due to cognitive processing differences (Woodeson et al., 2023). Dyslexic pupils, for instance, face challenges with phonological processing, making it difficult to recognize words. Furthermore, difficulties with working memory, as Bao (2023) highlighted, can hinder their ability to retain and recall new vocabulary. These cognitive challenges extend to understanding and interpreting idiomatic expressions, metaphors, and other complex linguistic nuances, significantly altering their language learning environment and experience. This situation underscores the need for specialized teaching approaches and tools that cater to their unique learning profiles.

On the other hand, vocabulary is more than just a collection of words; it provides the foundation for knowing, expressing, and connecting. An extensive vocabulary is equivalent to a complete communication toolset (Kai & Tan, 2021). However, deficiencies in this toolkit can cause many problems for people with learning difficulties. Given the frequent requirement to interpret unexpected words, their reading may lack fluidity. Without the correct language, expressing complex thoughts becomes difficult (VanUitert et al., 2020). Classroom conversations can be filled with misunderstandings, and even social encounters with peers can be loaded with communication stumbling blocks. In summary, the underlying problem is not simply obtaining words, but also effectively utilising them for meaningful communication.

2.2. The Importance of Vocabulary in Language Learning

Expanding one's vocabulary is integral to learning a foreign language and plays a crucial role in language instruction. However, teaching vocabulary can be challenging for teachers who may struggle to determine the most optimal strategies for vocabulary instruction (Al-Khresheh & Al-Ruwaili, 2020). Thornbury (2002) argues that while grammar is essential, vocabulary is the cornerstone of effective communication. A substantial vocabulary is necessary for language learners to express themselves proficiently (Cameron, 2001). Vocabulary can be defined as a collection of words specific to a language or a set of terms that a language speaker can use (Al-Ruwaili & Al-Khresheh, 2023). Linse (2005) defines vocabulary as an individual's word repertoire, while Hornby (2006) describes it as the words one employs or understands to convey a particular subject in a specific language. Bintz (2011) cites Neuman and Drawyer, emphasizing that vocabulary comprises the words required for effective communication. Therefore, a child's vocabulary consists of the words they understand in a given language, serving as a powerful tool for language development (Besthia, 2018; Elbro, 2010).

2.3. Key Skills in Vocabulary Learning

There are critical skills in vocabulary learning. Examining the critical skills involved in vocabulary learning is indispensable to fostering language proficiency and mastery. Word recognition is the foundational skill in vocabulary development, assuming that learners can identify and utilize sight words. Reading becomes possible as learners decode words into their constituent sounds. Exposure to various sources such as books, television, radio, newspapers, and magazines is vital in expanding vocabulary (Peterson et al., 2021). Therefore, learning new words extends away from reading books and encompasses reading newspapers, listening to the radio, and watching television.

Recall is another crucial skill in vocabulary development, requiring learners to thoroughly learn and store words in their long-term memory. Proficient recall necessitates a clear mental or auditory representation of the vocabulary term. Verbal-visual association tasks that involve sequential and phonological components can pose challenges for learners with learning impairments (Krishnan et al., 2017). Integrating innovative technologies into early childhood special education can enhance word recall and provide a more engaging learning experience (Ashoori, 2012).

Guessing the meaning of words from context is another critical skill in vocabulary acquisition. Contextual guessing involves making educated inferences about word meanings while reading or listening to enhance comprehension. Learners often rely on contextual clues, sentence structure, discourse, and

situational context to deduce word meanings (Zhou, 2014). Early childhood special education teachers utilize contextual guessing, memorization, and repetition techniques to teach new English phrases and support vocabulary learning.

Word production is also another important skill that involves actively using vocabulary. Speaking a word aloud during the learning process enhances recall and strengthens associations with related concepts. Individuals with a rich vocabulary demonstrate improved reading comprehension, oral communication, and writing skills. Utilizing newly learned words facilitates better retention and comprehension (Al-khresheh & Al-Ruwaili, 2020).

2.4. Augmented Reality Applications in Education

The significance of vocabulary development in early childhood education, particularly for students with learning disabilities, is paramount. These students often face challenges in assimilating new English vocabulary. It is critical to nurture their vocabulary growth during this key developmental stage, as studies indicate children can acquire around nine to ten new words weekly (Brown, 2015; Peterson et al., 2021). Integrating advanced educational tools like Augmented Reality (AR) in teaching strategies can markedly enhance language acquisition and the broader learning experience for these students. This highlights the necessity of adopting specialized educational methodologies tailored to meet the distinctive learning requirements of students with learning disabilities.

In classroom settings, vocabulary instruction holds significant importance for children who enter school with limited word knowledge. Children with linguistic impairments are more prone to experiencing reading difficulties (Brown, 2015). However, traditional approaches to teaching word meanings may not be feasible for effectively instructing large numbers of students due to the time required for vocabulary acquisition and the number of words involved (Peterson et al., 2021).

Teaching English vocabulary poses a considerable challenge for educators, which is further intensified when teaching children with learning disabilities. To address this issue, the current study utilized augmented reality AR applications to explore their impact on teaching English vocabulary to a group of early childhood pupils with learning disabilities.

Information technology plays a pivotal role in catering to the needs of students with learning disabilities (Digón Regueiro et al., 2024). AR applications emerged as a technology encompassing various definitions. According to Mohamed (2022), AR apps can be described as "educational tools and digital displays that blend virtual graphics with physical reality, deliberately designed with educational goals in mind to be employed within an educational setting to offer learners happiness, pleasure, and facilitate the learning process" (p. 19). Unlike virtual reality, AR does not disrupt the user's connection to the real world and enables the integration of virtual elements or perspectives into the actual environment (Khan et al., 2017; López-Belmonte et al., 2022). AR applications present novel approaches for engaging with the physical world and augmenting mixed-reality learning environments that combine virtual and real-world components. They facilitate the manipulation of virtual objects and enable the visualization of challenging-to-observe locations in the real world. AR offers an immersive educational journey, promoting critical thinking, deepening the understanding of challenging or intangible concepts, and rectifying misconceptions (Fernández Batanero et al., 2022).

AR technology seamlessly blends the virtual and physical worlds, augmenting the actual world rather than replacing it. Azuma (1997) identifies three pivotal characteristics of AR: the integration of actual and computer-generated elements, instantaneous communication, and the registration of real and virtual items with one another. AR aligns with three fundamental requirements, as outlined by Azuma: the fusion of actual and virtual worlds, genuine engagement, and precise recognition of three-dimensional objects (real and virtual).

Research suggests that AR applications hold great promise for the future of education (Khan et al., 2019; López-Belmonte et al., 2020; López-Bouzas & del Moral Pérez, 2022). Consequently, educational institutions should leverage this technology to benefit students, teachers, and institutions. Recent advancements in digital technologies, coupled with the capabilities of mobile devices, have made mobile AR applications readily accessible. The field of AR applications has expanded, and the utilization of AR apps has become simple and adaptable (Lv et al., 2021).

Utilizing AR technologies in early childhood education, particularly for pupils with learning disabilities, offers a distinct advantage by providing a technology-enriched learning environment. These tools can help reduce cognitive overload by integrating information from multiple sources, making learning more manageable and accessible. Furthermore, AR apps' immersive and interactive qualities actively engage students, boosting their enthusiasm and participation. This approach aligns with Khan et al. (2019) and Lv et al. (2021), who note AR's potential to create engaging, activity-driven, and realistic educational experiences, significantly enhancing student engagement and learning effectiveness.

Students can derive meaning from their interactions with AR applications through interactive exchanges and the analysis of mistakes. Moreover, learners can build upon existing knowledge and transfer newly acquired skills to unrelated settings. Teachers can monitor individual students and the social dynamics of the group, identifying areas of difficulty or success. The instructional process should be engaging, straightforward, enjoyable, and compatible with routine activities and the learning environment (Pivec & Dziabenko, 2004).

AR offers several advantages when incorporated into the classroom. Teachers can select from various ready-to-use AR options, simplifying technology integration into the learning environment. AR technology is widely used in textbooks, making it convenient for students who only need to bring their mobile devices to class (Lv et al., 2021).

For pupils with learning disabilities, engaging in task-based activities within the learning environment is essential. These activities can include various AR applications designed to make learning more enjoyable, fascinating, and fun while assisting students in word formation and usage across different contexts (Richardson, 2016). Studies have indicated that using AR applications improves students' academic performance, motivation, and vocabulary learning in EFL settings (Erbas & Demirer, 2019; Silva et al., 2013; Solak & Cakir, 2015).

Liu and Tsai (2013) examined how AR components enable young learners to access content actively and effectively, acquire language and subject matter knowledge, and develop writing skills. Silva et al. (2013) demonstrated that AR blocks could enhance young children's reading skills, employing quantitative and qualitative criteria to evaluate the tool's efficacy. The findings indicated that AR technology improves young children's academic achievement and reading skills, while instructors also expressed enthusiasm for its implementation. Santos et al. (2016) found that adopting AR applications can

enhance system usability and language retention. Furthermore, Chen and Chan (2019) demonstrated how AR could facilitate young children's vocabulary expansion and language acquisition. By making learning English vocabulary more enjoyable, AR can aid students in understanding and remembering the language (Rozi et al., 2021). Similarly, Fernández Batanero et al. (2022) summarized the current state of AR research in special education and showcased how AR can enhance learning outcomes for children with exceptional needs. Other studies have highlighted the benefits of AR-assisted games, including active learning, improved cultural understanding, and heightened language awareness (Hasbi & Yunus, 2021; Lai & Chang, 2021; Mielgo-Conde et al., 2022).

AR can be implemented through various devices and in diverse ways, catering to various students and learning styles. The gamified learning environment fostered by AR promotes student engagement, as learners tend to grasp concepts more effectively when interested. Games facilitate the integration of prior knowledge, organize learning experiences, and provide immediate feedback. Furthermore, contextual learning within games allows students to apply their knowledge to real-life situations. Students can acquire knowledge through games, personal experiences, problem-solving, and trial and error (Acquah & Katz, 2020; Ibrahim et al., 2018; Liu et al., 2016; Madanipour & Cohrssen, 2020).

Despite the growing body of research on the benefits of AR applications in educational settings, there remains a research gap regarding their specific impact on teaching English vocabulary to early childhood pupils with learning disabilities. While studies have demonstrated the efficacy of AR in enhancing academic achievement, motivation, and vocabulary learning, there is limited research that specifically focuses on its application in the context of learners with special needs. Therefore, this study aims to address this research gap by investigating the effects of AR apps on vocabulary development in a group of early childhood pupils with learning disabilities, thereby contributing to the existing literature on the effective integration of AR technology in inclusive educational practices.

3. MATERIAL AND METHOD

This study aimed to determine AR applications' effectiveness in improving the vocabulary of early childhood pupils with learning disabilities. In light of this, the study proposed the following hypothesis: The AR technology strategy affects vocabulary learning for pupils with disabilities.

3.1. Research Design

The quasi-experimental technique was used in this study to demonstrate a cause-and-effect relationship between a dependent and independent variable. A quasi-experimental design is a research approach where participants are not randomly assigned to conditions. It is used when controlled, random assignment is impractical, allowing for causal inferences with some limitations due to non-randomization (Gay & Airasian, 2005). A quasi-experiment does not employ random assignment in contrast to an actual experiment. Instead, individuals are divided into specific groups based on non-random criteria. Without randomization, this experimental study design can simulate an experiment and provide a high level of evidence.

It allows the researchers to control the variables (Babbie, 2005). This method was chosen because it helps observe the independent variable effect (AR technology) on the dependent variable (Vocabulary Learning) while adjusting other related variables. Pre- and post-testing were mainly carried out on 30 students chosen purposely and divided into experimental and control groups. The experimental group was subjected to teaching using the AR technology strategy (See Appendix 1). The control group received the conventional approach, a traditional way of teaching vocabulary using flashcards, photographs, wall charts, relia, and translation techniques. As previously stated, an AR app integrates numerical visual material (audio and other categories) into the user's real-world surroundings. The research utilized an augmented reality application developed expressly for the examined curriculum. When a learner places his smartphone's camera on a book page, the text is animated into a video, interactive exercise, and game-based activity that allows him to practice in-text vocabulary. These elements may facilitate vocabulary development for early childhood with learning disabilities. Such programs are believed to generate a joyous and pleasant ambience in the pupils' hearts. After the experiment, the two groups were statistically compared.

The quasi-experimental design depends on two variables. The independent variable is the element or causes used to determine its impact on the result. The study's independent variable is the use of AR technology. The outcome is the dependent variable, which is used to evaluate the impact of the independent variable. The dependent variable in this study is vocabulary learning skills.

3.2. Participants

A purposive sampling strategy was utilized to choose a sample of 30 pupils diagnosed with learning disabilities by the school's special needs section, where all necessary data is available. Pupils with learning disabilities were purposively chosen from two separate schools. It is known that the purposive sampling method enables researchers to examine the ramifications of their results for the entire population (Gay & Airasian, 2005). Identifying pupils with learning disabilities was facilitated through dedicated resource rooms in each participating school. These rooms hold detailed educational profiles for students with special needs. A thorough examination of these records and consultations with educational experts in these environments enabled a precise selection of pupils who stood to gain significantly from integrating AR technology into their vocabulary learning. This method ensured a focused and effective application of AR resources, targeting those most likely to benefit. The participants have the same socioeconomic background. Their native language is Arabic. English is a required course for all pupils. They have been learning it for over five years. They have been taught vocabulary as part of the English curriculum. They were all nine years old on average. In this study, individual phone calls to parents were a procedural step for obtaining consent and an opportunity to engage them in the study's objectives. This engagement likely influenced the results, as parental understanding and support could have impacted pupils' responses and participation. Parental agreement may have provided a more conducive environment for the pupils, potentially affecting their enthusiasm and engagement with the AR technology. Recognizing the influence of parental attitudes and support in educational research is crucial, as it can shape the children's experiences and responses within the study context.

3.3. Instrument

A test was developed and used to achieve the main study's objective. The test was constructed based on the literature to cover primary vocabulary skills, recognition, recall, guessing, and production. Each skill was assigned a set of questions. The terminology for the test came from the students' textbooks. Four questions were developed to assess pupils' vocabulary achievement considering their learning disabilities. The first question assesses their recognition skill. Therefore, the question required pupils to look at the photographs and unscramble the words, which included six items. The second question had four items that required students to look, listen, and number. Looking at the picture provided and listening to their pronunciation help them remember and recall their meanings. The third question had five items, and pupils had to match the text to the proper photographs in each item. Photographs were viewed as hints to aid in deciphering the meaning and matching it with the appropriate word. The last question consisted of six items. Pupils were instructed to look at the photographs and fill in the blank letters in each item. Filling in the blanks reflects production skills. The total exam score was (40) (See Appendix 2 & 3). The test was the most effective way to evaluate the participants' vocabulary knowledge. Ary et al. (2018) defined a test as a set of stimuli shown to an individual to elicit responses from which a score may be assigned. The same pupils were tested before and after adopting the AR teaching technique (pre and post-test). The pupils were given explicit instructions (See Appendix 2 & 3).

As stated earlier, the experimental group was instructed via the AR application. Vuforia software was used to construct this application, which can be viewed on smartphones and iPad tablets. Vuforia was chosen for its sophisticated AR features, such as strong tracking and real-time rendering, which made it well-suited to the study's aims. Its broad compatibility and user-friendly interface also played a role in the selection, allowing for the fast creation and execution of the AR applications utilized in the study. Utilizing the program's three-dimensional visuals, audio, and animated movements, pupils may learn new vocabulary words. The AR application stimulates the pupils' senses and gives them new linguistic experiences and information. Before letting students utilize the AR program on their smart devices to learn new vocabulary, teachers reviewed how the AR application functioned with the class.

3.4. The Test's Validity

The pre/post-test was given to a jury of curriculum and teaching experts to examine the appropriateness of its items in order to verify its content validity. The jury, comprising curriculum and special education specialists, was carefully selected based on their profound knowledge of language teaching and AR technologies. Their comprehensive evaluation of the test's content, focusing on its applicability and relevance for students with learning disabilities, ensured its content validity. This rigorous validation by seasoned professionals affirmed the test as a dependable tool for assessing vocabulary development. For each question, a set of 35 objects was presented. The jury was tasked with selecting the most relevant ones. As a result, 20 items were chosen from the four primary assessed vocabulary skills. Table 1 shows the percentage of the jury's agreement and disagreement on the adequacy of the test content.

TABLE 1. The Percentage of Agreeing and Disagreeing on the Test Suitability

Question no.	Agreeing on suitability	Disagreeing on suitability
1	90%	10.0%
2	100%	0.0%
3	80%	20.0%
4	100%	0.0%

The coefficient validity was also tested for more accuracy. Calculating the correlation coefficients between the test questions and the overall score, then calculating the correlation coefficients between each sub-skill and the total score for this skill, determines the test's coefficient validity. The reciprocal correlation coefficients are computed between each sub-skill of the test and its overall score in the third phase. Consequently, Table 2 displays the results of the first phase, and Table 3 displays the results of the second step. The findings of the third phase in calculating internal consistency are shown in Table 4.

TABLE 2. Correlation Coefficients between each Test Question and the Total Test Score

Questions	The correlation between the test scores	Questions	The correlation between the test scores
1	0.84**	11	**0.81****
2	0.80**	12	**0.39***
3	0.47**	13	**0.87****
4	0.52**	14	**0.81****
5	0.58**	15	**0.39***
6	0.37*	16	**0.76****
7	0.87**	17	**0.81****
8	0.45**	18	**0.46****
9	0.41**	19	**0.44****
10	0.80**	20	**0.82****

Note:**. The difference is significant at the 0.01 level.
Note:*. The difference is significant at the 0.05 level.

The preceding table demonstrates the significance of the correlation coefficients between the test questions and the test's total score. These coefficients were mainly significant at levels (0.01) and (0.05). This means that the test has passed the first step of internal consistency validity. Table 3 displays the values of the correlation coefficients between the test questions and the overall score for the primary skills to which they belong.

TABLE 3. Correlation Coefficients between each of the Test Questions and the Total Score for the Main Skills

Recognition		Recall		Guessing		Production	
Item No	Correlation Coefficients	Item No	Correlation Coefficients	Item No	Correlation Coefficients	Item No	Correlation Coefficients
1	0.85**	1	0.88**	1	0.87**	1	0.76**
2	0.83**	2	0.49**	2	0.86**	2	0.61**
3	0.56**	3	0.45**	3	0.79**	3	0.74**
4	0.56**	4	0.83**	4	0.61**	4	0.84**
5	0.59**			5	0.91**	5	0.64**
6	0.46**						

Table 3 demonstrates that the correlation coefficients were significant at the level (0.01), indicating that the test passed the second stage of internal consistency validity. Table 4 demonstrates that all the correlation coefficients between the four sub-skills of the test and between them and the total test score were significant at the significance level (0.01). This marks the completion of the third level of the vocabulary achievement test's internal consistency. These findings thoroughly support the validity of the vocabulary achievement test in assessing what it was designed to measure, lending confidence to its use in the current study.

TABLE 4. The Matrix of Correlation Coefficients between the Sub-skills of the Vocabulary Achievement Test and Its Total Score

SKILLS	Recognition	Recall	Guessing	Production	Total Score
Recognition	-	0.86**	0.93**	0.91**	**0.97****
Recall		-	0.83**	0.96**	**0.95****
Guessing			-	0.97**	**0.94****
Production				-	**0.96****

3.5. The Test's Reliability

Ahead of the main study, a pilot study was carried out to ensure the test's reliability. Twenty pupils were tested twice at different times. They are a representative sample of the main study's participants. They were excluded from the main study. Cronbach's alpha was used to determine the reliability coefficient value, one of the most significant reliability coefficients (0.842). This implies that the test is reliable and trustworthy, allowing the researcher to apply it confidently to the study's primary sample. The reliability coefficients for each skill are displayed in Table 5. Furthermore, during the piloting, the researchers could determine the time required to complete the exam by adding the time taken by the first student to the time spent by the last one and dividing the total time by two. The average time required to complete the exam was (40) minutes.

TABLE 5. Reliability coefficients for all skills

SKILL	RELIABILITY COEFFICIENTS
Recognition	0.802
Recall	0.713
Guessing	0.762
Production	0.793
Overall Cronbach's alpha	0.842

3.6. Data Collection and Analysis

The study took place throughout the second academic semester of the academic year 2021-2022. The main study was conducted fifteen days following the pilot study. Permission was obtained from the two schools where the pilot and primary studies were carried out.

The test administration to pupils with learning disabilities was methodically tailored with specific adjustments to address their unique needs. The process involved employing straightforward language, allowing additional time, and creating a distractions-free environment. Specialist educators were integral in

overseeing the testing, ensuring a comfortable and supportive setting for effective participation by each pupil. These strategic accommodations were vital in aligning the data collection with the specific educational requirements of the pupils, thereby preserving the validity and reliability of the test outcomes.

Two experienced teachers were involved in this study. They have an outstanding track record of teaching performance reviews. They were both familiar with the use of AR. Because the AR application was optional, most teachers did not use it throughout the lesson. During the three-month teaching period, the researchers paid weekly visits to the teachers, monitored their performance, and ensured that this application was used in the experimental group. The supplementary English classes were held three times a week for 45 minutes. These extra classes were exclusively offered to students who had learning disabilities.

In this research, the control group was taught using conventional instructional methods, serving as a benchmark for evaluating the AR technology's impact. This traditional educational approach was maintained without specific alterations for the study, encompassing regular classroom teaching and standard curriculum materials. This methodological decision was pivotal in establishing a clear comparative framework with the experimental group utilizing AR, thereby allowing for an objective evaluation of AR's effectiveness in aiding vocabulary development for pupils with learning disabilities.

The additional sessions are divided into three primary parts: a warm-up, an AR lesson presentation, and an understanding assessment. The teacher always starts the instructional sessions to grab the pupils' attention and introduce the lesson topic and objectives. Pupils are then instructed to open their books to the page where the AR application will be used. Pupils can use their smart devices to acquire new vocabulary and participate in interactive activities by pointing their cameras at the lesson page. Depending on the instructions, pupils may complete the assignment individually, in pairs, or groups. In order to gauge how well the pupils understand the new language, the teacher gives out a worksheet. When feasible, he gives feedback and praises the pupils' accomplishments (See Appendix 4).

After marking the tests, the SPSS 28 program was used to analyze the data. There was a pre-test and a post-test. The following statistical methods were used:

- The Mann-Whitney test for comparison between two independent groups to test the hypothesis related to the study of the statistically significant differences between the mean scores of individuals (the experimental group and the control group), whether before or after applying the experiment.
- Rank Biserial correlation to calculate the effect size.
- Wilcoxon Test" for two related samples and its statistical significance for the differences between the mean scores of the experimental group in the pre and post-test.
- Pearson correlation coefficient to verify the validity of the test.
- Cronbach's Alpha equation in calculating the test reliability coefficient.

Given this, the tabulation method was used in this study for data presentation.

3.7. Ethical Considerations

This study adhered to strict ethical guidelines. We obtained informed consent from both schools involved and the parents of all participating pupils, ensuring full awareness of the study's aims and methodology. The rights of participants, especially regarding confidentiality and voluntary engagement, were upheld. Special attention was given to the sensitivities of working with children with learning disabilities, guaranteeing respectful and considerate interactions. Data management, including test results and observations, was conducted with utmost confidentiality and security, prioritizing participant privacy throughout the research process.

4. RESULTS

The vocabulary achievement test was administered to the two groups before the experiment began to ensure that the two groups (experimental and controlled) were equal. The researchers adjusted the tests and computed the scores to confirm that the two groups were alike in the study variables. As indicated in Table 6, the Mann-Whitney test and its statistical significance for the differences between the experimental and control groups' mean scores in the pre-test were used.

TABLE 6. Results of the Mann-Whitney Test for Finding Differences between the Control and Experimental Groups on the Pre-Test

SKILLS	Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z-Score	Asymptotic Sig. (2-tailed
Recognition	Experimental	15	15.53	233.00	112.00	-.022	0.982
	Control	15	15.47	232.00			
Recall	Experimental	15	15.97	239.50	105.50	0.306-	0.759
	Control	15	15.03	225.50			
Guessing	Experimental	15	15.77	236.50	108.50	-0.173	0.863
	Control	15	15.23	228.50			
Production	Experimental	15	15.87	238.00	107.00	-.241	0.810
	Control	15	15.13	227.00			
Total	Experimental	15	15.57	233.50	111.50	-.042	0.967
	Control	15	15.43	231.50			

Table 6 shows no statistically significant differences at the significance level (0.05) between the experimental and control groups' mean scores in the level of all vocabulary learning skills before applying the AR technology strategy. Thus, it could be stated that there is parity between the two groups (controlled and experimental) before applying (using) the AR technology strategy.

To answer the study question, the researchers validated the study's hypothesis, which suggests statistically significant differences at the level of statistical significance (= 0.05) between the mean scores of the control group taught traditionally and the experimental group taught by AR technology. To test the hypothesis, the researchers utilized the Mann-Whitney test and its statistical significance for the differences in mean scores between the experimental and control groups in the post-test, as shown in Table 7 (next page).

TABLE 7. Results of the Mann-Whitney test for Finding Differences between the Control and Experimental Groups on the Post-Test

SKILL	Class/Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	*Z-Score*	Asymptotic Sig. (2-tailed
Recognition	Experimental	15	22.47	337.00	8.00	4.385-	0.000*
	Control	15	8.53	128.00			
Recall	Experimental	15	21.47	322.00	23.00	3.776-	0.000*
	Control	15	9.53	143.00			
Guessing	Experimental	15	19.37	290.50	54.500	2.445-	0.014*
	Control	15	11.63	174.50			
Production	Experimental	15	22.70	340.50	4.500	4.520-	0.000*
	Control	15	8.30	124.50			
Total	Experimental	15	22.93	344.00	1.000	4.687-	0.000*
	Control	15	8.07	121.00			

Note: **The difference is significant at the 0.01 level of significance.

Table 7 demonstrates significant differences (0.05) concerning the experimental and control groups' post-test scores in all vocabulary skills (recognition, recall, guessing, and production) and the overall skill level. These differences favour the experimental group, with significance levels of (0.000, 0.000, 0.014, 0.000, 0.000) respectively. This value is less than the significance threshold (0.05), indicating that it is statistically significant. The average dimensional measurement scores of the experimental group pupils in the (Vocabulary Achievement post-test) were significantly higher than those of the control group students. This suggests that the use of AR technology in education affected the improvement and growth of the skills (recognition, recall, guessing, and production) and the overall level of skills of the participants in the experimental group.

In order to determine the impact of the teaching method according to the AR technology strategy on the development of (recognition, recall, guessing, and production) skills and on the level of skills as a whole, which is the complementary aspect of statistical significance (Rank biserial correlation ( )) was calculated as in Table 8 below.

TABLE 8. The Effect Size of AR Technology

SKILLS	r_{rb}	EFFECT SIZE
Recognition	0.93	**very high**
Recall	0.80	**High**
Guessing	0.52	**Moderate**
Production	0.96	**very high**
Total	0.99	**very high**

Looking at the impact size data in Table 8, it is evident that the effect size ranged from medium to very high. This demonstrates the efficacy of the AR technology technique for increasing vocabulary skills (recognition, recall, guessing, and production). This also demonstrates that the difference between the experimental and control groups is a fundamental difference caused by using the AR technology technique in education. The study's hypothesis can now be accepted in light of this finding.

The efficiency of the AR technology in developing (recognition, recall, guessing, and production) skills among experimental group students was assessed by statistical analyses of pre and post-test data for the experimental group only. Table 9 shows the "Wilcoxon Test" and its statistical significance for differences in the mean scores of the experimental group in the pre-and post-tests.

TABLE 9. Analysis of Experimental Group Pre-Test and Post-Test Scores

SKILL		N	Mean Rank	Sum of Ranks	z	Asymptotic Sig. (2-tailed)
Recognition	Negative Ranks	0	0.00	0.00	-3.426	0.001*
	Positive Ranks	15	8.00	120.00		
	Ties	0				
Recall	Negative Ranks	0	0.00	0.00	-3.421	0.001*
	Positive Ranks	15	8.00	120.00		
	Ties	0				
Guessing	Negative Ranks	0	0.00	0.00	-3.436	0.001*
	Positive Ranks	15	8.00	120.00		
	Ties	0				
Production	Negative Ranks	0	0.00	0.00	-3.425	0.001*
	Positive Ranks	15	8.00	120.00		
	Ties	0				
Total	Negative Ranks	0	0.00	0.00	-3.415	0.001*
	Positive Ranks	15	8.00	120.00		
	Ties	0				

As shown in Table 9, there are statistically significant differences at the level of significance (0.05) between the experimental group's mean scores in the pre and post-test on the four vocabulary skills (recognition, recall, guessing, and production) and on the overall level of skills in favour of the post-test. This also indicates that the differences in achievement were not due to chance but rather to the influence of the teaching technique based on AR technology.

5. DISCUSSION

Participants showed a difference in pre- and post-assessment scores between the traditional and AR technology of teaching vocabulary. Traditionally, participants did not show a noticeable variation between their pre- and post-assessment ratings. In contrast, utilizing the AR method consistently improved average pre- and post-assessment scores. This solid improvement was apparent in the high scores achieved by the experimental group in the four subs skills of vocabulary: recognition, recall, guessing, and production. The experimental group scored higher on the post-test because incorporating new methods into the school curriculum, such as integrating AR technology, enhances students' learning, aids in language development, and boosts students' learning, knowledge, motivation, and achievement. The visual aspects of AR technology play a crucial role in engaging users and maintaining their focus. This aspect of AR aligns with the observations of Santos et al. (2016), who noted that AR's capabilities in information visualization allow users

to form meaningful connections between the content and their environment. This interactivity enhances the learning experience by making it more immersive and contextually relevant. The learners' auditory and visual senses may be stimulated only using traditional vocabulary teaching methods. Nevertheless, when students use AR apps to help them study, their visual and aural senses are stimulated by 3D videos and images. Their kinesthetic senses are enhanced by operating their smartphones and tablets and connecting with their peers. This observation is consistent with the findings of Lai & Chang (2021) and Bonetti et al. (2018), who found that learning via AR often occurs near-spontaneously as learners are immersed in new language contexts within their AR environments. This immersive experience, providing first-hand exposure to new language items, facilitates a deeper and more intuitive understanding, underscoring the effectiveness of AR in language acquisition.

The current study created an AR application to support language learning in early childhood with learning disabilities. Images, films, and animation were among the multimedia components of the AR application. Students could stay motivated and interested in what they were learning since their regular sources of distraction were lessened. This was demonstrated by using digital games AR in the classroom to increase student motivation and enhance learning outcomes. Mobile phones, frequently a significant distraction source for students, become an engaging tool when used as a teaching tool to immerse students in their AR world. Students could better concentrate on their lessons by using their phones as a tool and minimizing distractions. Additionally, distractions from the classroom or peer pressure were minimized because students' VR headgear covered everything to save their AR surroundings. Students could recognize, recall, guess, and produce words when fully engaged in their AR surroundings.

Likewise, pupils utilizing AR applications showed enhanced performance for reasons such as the AR content being tailored to their interests and needs and the technology's support in learning at an individual pace. This customizability and adaptability of AR contributed to their learning efficacy. These outcomes are in line with the research of Binhomran and Altalhab (2021), Busra et al. (2021), Kellems et al. (2020; 2021), and Sadikin and Martyani (2020) affirming the positive impact of AR in meeting diverse educational requirements of pupils.

The findings revealed that AR technology significantly enhanced the learning experience, making it more interactive, enjoyable, and meaningful for pupils. The technology's facilitation of active engagement and collaboration was notable, particularly in activities featuring animations. This enhanced group interaction and cooperative learning approach align with Hasbi and Yunus's (2021) assertion on the efficacy of collaborative learning in classrooms. It underscores the role of AR in promoting social interaction, student-centred activities, and learner autonomy, thereby transforming the educational process into a more dynamic and inclusive experience. The researchers were intrigued by the fact that young children could utilize their cell phones, which are often distracting, as an educational tool to immerse themselves in their AR environment. This transformed their distraction into an instrument that piqued their interest in studying. Students were better able to pay attention to what they were studying due to using their phones as tools and reducing distractions. Instead of being taught a term to memorize, students might utilize the meanings to create real-world examples and connections. These findings align with Tyson's (2021) research, suggesting successful technology integration in learning. However, a notable contrast arises with Kathryn

et al. (2004), who observed challenges in children with learning disabilities using similar technology. The discrepancy highlights the variability in technology's effectiveness across different learner groups and emphasizes the need for tailored approaches in educational technology implementation, particularly for learners with specific needs.

This study also found that students' learning performance dramatically increased, indicating that AR helped them learn more effectively. This outcome defies the conclusions made by Lai and Chang (2021). They found that adding AR to the learning process did not significantly alter students' learning performance compared to conventional learning methods. They concluded that the experiment needed to be broadened to assess how the use of AR applications affected students' learning performance.

Acknowledging the focused scope of this research, the findings provide a preliminary understanding of the efficacy of AR technology in special education settings. While the results offer valuable insights, they also underscore the need for more expansive studies in various educational environments. Such extended research is critical to fully appreciate the potential and limitations of AR technology in enhancing learning experiences for diverse groups of students, especially those with unique educational needs.

5.1. Implications

The study underlines the pivotal role of AR in supporting early childhood pupils with learning disabilities. AR does not merely enhance vocabulary learning; it potentially paves the way for enriched reading comprehension. The immersive quality of AR captivates learners, cultivating a more profound interest in English. This interactive learning environment enriches the educational experience and fosters a positive attitude and heightened self-assurance among students, as reflected in their improved post-test outcomes. The broader ramifications suggest that AR's potential extends beyond vocabulary to encompass other facets of English language instruction. Ramping up educator training focused on AR's educational applications is imperative to harness this potential fully. Recognizing AR's transformative impact, curriculum developers should proactively integrate it into language instruction modules. While illuminating in its findings, this research also beckons further exploration into how AR can revolutionize the educational landscape for young learners with disabilities.

6. CONCLUSIONS

This study underscores the transformative potential of AR in enhancing vocabulary instruction for early childhood pupils with learning disabilities. A marked improvement was observed in the post-assessment scores of the experimental group, exposed to AR-based learning, compared to the control group. The integration of AR not only minimized distractions but also amplified student engagement, leading to enhanced word recognition, recall, and linguistic production. Given these outcomes, curriculum designers are urged to embed AR applications with vibrant visuals in early childhood textbooks. Concurrently, educators should prioritize vocabulary retrieval strategies to bolster the expressive skills of students with learning disabilities, with the study suggesting tailored AR applications as a potent tool in this endeavour.

6.1. Limitations and future lines of research

The research presents certain limitations due to its methodological approach and participant selection. The sample, derived exclusively from two schools and comprising a limited number of early childhood pupils with learning disabilities, restricts the sample size and, consequently, the generalizability of the findings. While insightful, the study's focus on vocabulary learning does not encompass other critical areas, such as speaking and reading comprehension. Moreover, by concentrating solely on early childhood pupils with a specific type of disability, the study does not represent a broader range of disabilities.

Recommendations for future research include broadening the scope to incorporate larger and more diverse samples and extending study durations to provide a more holistic understanding of AR technology's impact. There is also a pressing need for developing and implementing innovative technologies that facilitate early identification and continuous support for early childhood pupils with diverse learning disabilities, thereby potentially enhancing educational outcomes and experiences.

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8. REFERENCES

Acquah, E., & Katz, H. (2020). Digital game-based L2 learning outcomes for primary through high-school participants: A systematic literature review. *Computers & Education, 143*(1). https://doi.org/10.1016/j.compedu.2019.103667

Adlof, S., Baron, L., Bell, B., & Scoggins, J. (2021). Spoken word learning in children with developmental language disorder or dyslexia. *Journal of Speech, Language, and Hearing Research*, *64*(7), 2734-2749. https://doi.org/10.1044/2021_JSLHR-20-00217

Ali, M. A. (2020). Investigation of vocabulary learning strategies to identify word meanings for Saudi EFL students in reading context. *Arab World English Journal*, *11*(3) 149-169. https://dx.doi.org/10.24093/awej/vol11no3.9

Alkhattabi, M. (2017). Augmented reality as e-learning tool in primary schools' education: barriers to teachers' adoption. *International Journal of Emerging Technologies in Learning 12*(02), 91–100. https://doi.org/10.3991/ijet.v12i02.6158

Al-khresheh, M. (2020). A comparative study of language development in monolingual and bilingual children with autism spectrum disorders. *International Journal of English Linguistics, 10*(6), 104-117. https://doi.org/10.5539/ijel.v10n6p104

Al-khresheh, M. & Al-Qadri, A. (2021). The language development process of bilingual children with autism spectrum disorder: An investigation into gender linguistic differences. *World Journal of English Language*, *11*(2), 29-42. https://doi.org/10.5430/wjel.v11n2p29

Al-khresheh, M., & Al-Ruwaili, S. (2020). An exploratory study into vocabulary learning strategies used by Saudi EFL learners. *Journal of History Culture and Art Research*, *9*(2), 288-302. https://doi.org/10.7596/taksad.v9i2.2616

Al-khresheh, M., Mohamed, A. M., & Asif, M. (2022). Teachers' perspectives towards online professional development programs during the period of COVID-19 pandemic in the Saudi EFL context. *FWU Journal of Social Sciences, 16*(2). 1-14.

Al-Qadri, A., Zhao , W., Li, M., Al-khresheh, M., & Boudouaia, A. (2021). The prevalence of the academic learning difficulties: An observation tool. Heliyon, 7(10), 1-12. https://doi.org/10.1016/j.heliyon.2021.e08164

Al-Ruwaili, S. & Al-Khresheh, M. (2023). Understanding teachers' beliefs about effective vocabulary instruction in the Saudi tertiary EFL context. *Journal of the North for Humanities, 8*(1), 345-356.

Ary, D., Jacobs, L., Irvine, C., & Walker, D. (2018). *Introduction to research in education*. Cengage Learning.

Ashoori, A. (2012). Recall of foreign-language vocabulary: effects of keyword, context and word list instructional strategies on long-term vocabulary recall of EFL learners. *Journal of theory and practice in education*, *8*(1), 54-7.

Azuma, R. (1997). A survey of augmented reality. *Teleoperator and Virtual Environments*, *6*(4), 3-5. https://doi.org/10.1162/pres.1997.6.4.355

Babbie, E. (2005). *The basic of social research*. Wadsworth Publishing Company.

Balikci, O., & Melekoglu, M. (2020). Early signs of specific learning disabilities in early childhood. *International Journal of Early Childhood Special Education*, *12*(1), 84-95. https://doi.org/10.20489/intjecse.722383

Bao, L. (2023). Special Vocabulary Learning Difficulties for EFL Students with Chinese Backgrounds. *Pacific International Journal*, *6*(2), 108-116. https://doi.org/10.55014/pij.v6i2.360

Besthia, W. (2018). A survey on vocabulary learning strategies: A case of Indonesian EFL university students. *Journal of Research & Method in Education, 8*(5), 636-641.

Binhomran, K. & Altalhab, S. (2021). The impact of implementing augmented reality to enhance the vocabulary of young EFL learners. *The JALT CALL Journal*, *17*(1), 23-44. https://doi.org/10.29140/jaltcall.v17n1.304

Bintz, W. (2011). Teaching vocabulary across the curriculum. *Middle School Journal*, *42*(4), 44-53.

Bonetti, F., Warnaby, G.& Quinn, L. (2018). Augmented Reality and Virtual Reality in Physical and Online Retailing: A Review, Synthesis and Research Agenda. In T. Jung, M. tom Dieck (Eds.), *Augmented Reality and Virtual Reality* (pp. 119-132). *Progress in IS*. Springer. https://doi.org/10.1007/978-3-319-64027-3_9

Booton, S., Hodgkiss, A. & Murphy, V. (2021). The impact of mobile application features on children's language and literacy learning: a systematic review. *Computer Assisted Language Learning*, *34*(1), 1-30. https://doi.org/10.1080/09588221.2021.1930057

Brown, T. (2015). *An exploratory study of vocabulary instruction in inclusive preschool classrooms*. Kent State University.

Buchner, J., & Kerres, M. (2023). Media comparison studies dominate comparative research on augmented reality in education. *Computers & Education, 195,* 104711. https://doi.org/10.1016/j.compedu.2022.104711

Busra. Y., Funda, E., & Samed Y. (2021). Augmented reality for learning in special education: a systematic literature review, *Interactive Learning Environments*, *8(1),* 1–17. https://doi.org/10.1080/10494820.2021.1976802

Cameron, L. (2001). *Teaching languages to young learners*. Cambridge University Press.

Chen, R., & Chan, K. (2019). Using augmented reality flashcards to learn vocabulary in early childhood education. *Journal of Educational Computing Research*, *57*(7), 1812-1831. https://doi.org/10.1177/0735633119854028

Colenbrander, D., Miles, K., & Ricketts, J. (2019). To see or not to see: How does seeing spellings support vocabulary learning? *Language, speech, and hearing services in schools*, *50*(4), 609-628. https://doi.org/10.1044/2019_LSHSS-VOIA-18-0135

Digón Regueiro, P., Méndez García, R. M., Romero Rodrigo, M. M., & Becerra Brito, C. V. (2024). Questioning the role of technology in Early Childhood Education: divides and false views. *Pixel-Bit. Media and Education Journal*, (69), 63-96. https://doi.org/10.12795/pixelbit.98498

Elbro, C. (2010). Dyslexia as disability or handicap: When does vocabulary matter? *Journal of Learning Disabilities*, 43(5), 469-478. https://doi.org/10.1177/0022219409357349

Eldokhny, A., & Drwish, A. (2021). Effectiveness of augmented reality in online distance Learning at the Time of the COVID-19 Pandemic. *International Journal of Emerging Technologies in Learning, 16*(09),198–218. https://doi.org/10.3991/ijet.v16i09.17895

Erbas, C., & Demirer, V. (2019). The effects of augmented reality on pupils' academic achievement and motivation in a biology course. *Journal of Computer Assisted Learning, 35(3), 450-458.* https://doi.org/10.1111/jcal.12350

Fernández-Batanero, J., Montenegro-Rueda, M., & Fernández-Cerero, J. (2022). Use of augmented reality for students with educational needs: A systematic review (2016–2021). *Societies*, *12*(2), 36. https://doi.org/10.3390/soc12020036

Gay, L., & Airasian, P. (2005). *Educational research: Competencies for analysis and application* (8th edition). Merrill Prentice Hall.

Hasbi, A., & Yunus, M. (2021). The effectiveness of augmented reality for English (AR4E) in vocabulary learning among primary 2 pupils. *International Journal of Education*, *13(1),1-14*. https://doi.org/10.5296/ije.v13i3.18808

Hornby, A. (2006). *Oxford Advanced Learner's Dictionary*. Oxford University Press.

Ibrahim, A., Huynh, B., Downey, J., Hollerer, T., Chun, D., & Odonovan, J. (2018). ARbis pictus: A study of vocabulary learning with augmented reality. *IEEE Transactions on Visualization and Computer Graphics, 24*(11), 2867-2874. https://doi.org/10.1109/tvcg.2018.2868568

Kai, T., & Tan, K. (2021). Enhancing English language vocabulary learning among Indigenous learners through Google Translate. *Journal of Education and e-Learning Research*, *8(1),* 143-148. https://doi.org/10.20448/journal.509.2021.82.143.148

Kathryn D., Light, J.., Carlson, R., D'Silva, K., Larsson, B., Pitkin, L., & Stopper, G. (2004). Learning of dynamic display AAC technologies by typically developing 3-year-olds. *Journal of Speech, Language, and Hearing Research, 47*(5), 1133-1148. https://doi.org/10.1044/1092-4388(2004/084)

Kellems, R. O., Cacciatore, G., Hansen, B. D., Sabey, C. V., Bussey, H. C., & Morris, J. R. (2021). Effectiveness of video prompting delivered via augmented reality for teaching transition-related math skills to adults with intellectual disabilities. *Journal of Special Education Technology, 36*(4), 258-270. https://doi.org/10.1177/0162643420916879

Kellems, R., Eichelberger, C., Cacciatore, G., Jensen, M., Frazier, B., Simons, K., & Zaru, M. (2020). Using video-based instruction via augmented reality to teach mathematics to middle school pupils with learning disabilities. *Journal of Learning Disabilities*, *53*(4), 277-291. https://doi.org/10.1177/0022219420906452

Kennedy, M., Deshler, D., & Lloyd, J. (2015). Effects of multimedia vocabulary instruction on adolescents with learning disabilities. *Journal of Learning Disabilities*, *48*(1), 22-38. https://doi.org/10.1177/0022219413487406

Khan, M., Hussain, M., Ahsan, K., Saeed, M., Naddem, A., Air, S., Mahmood, N., & Rizwan, K. (2017). Augmented reality-based spelling assistance to dysgraphia pupils. *Journal of Basic & Applied Sciences*, *13*, 500-507. https://doi.org/10.6000/1927-5129.2017.13.82

Khan, T., Johnston, K., & Ophoff, J. (2019). The impact of an Augmented Reality application on learning motivation of students. *Advances in Human-Computer Interaction, 2019*, 1–14. https://doi.org/10.1155/2019/7208494

Kouvava, S., Antonopoulou, K., Ralli, A., Kokkinos, C., & Maridaki-Kassotaki, K. (2022). Children's vocabulary and friendships: A comparative study between children with and without specific learning disorder and attention deficit hyperactivity disorder. *Dyslexia*, *28*(2), 149-156. https://doi.org/10.1002/dys.1709

Krishnan, S., Watkins, K., & Bishop, D. (2017). The effect of recall, reproduction, and restudy on word learning: a pre-registered study. *BMC Psychology*, *5*(1), 1-14. https://doi.org/10.1186/s40359-017-0198-8

Lai, J., & Chang, L. (2021). Impacts of augmented reality apps on first graders' motivation and performance in English vocabulary learning. *SAGE Open*, *11*(4). https://doi.org/10.1177/21582440211047549

Linse. T. (2005). *Practical English language teaching: Young learners*. McGraw-Hill.

Liu, P., & Tsai, M. (2013). Using augmented-reality-based mobile learning material in EFL English composition: An exploratory case study, *British journal of educational technology*, *44*(1), 1-4. https://doi.org/10.1111/j.1467-8535.2012.01302.x

Liu, Y., Holden, D., & Zheng, D. (2016). Analyzing pupils' language learning experience in an augmented reality mobile game: An exploration of an emergent learning environment. *Procedia - Social and Behavioral Sciences*, 228(June), 369-374. https://doi.org/10.1016/j.sbspro.2016.07.055

López-Belmonte, J., Moreno-Guerrero, A. J., López-Núñez, J. A., & Hinojo-Lucena, F. J. (2020). Augmented reality in education. A scientific mapping in Web of Science. *Interactive Learning Environments, 31*(4), 1860-1874. https://doi.org/10.1080/10494820.2020.1859546

López-Belmonte, J., Moreno-Guerrero, A. J., Marín-Marín, J. A., & Lampropoulos, G. (2022). The Impact of Gender on the Use of Augmented Reality and Virtual Reality in Students with

ASD. *Education in the Knowledge Society (EKS), 23*. https://doi.org/10.14201/eks.28418

López-Bouzas, N., & del Moral Pérez, M. E. (2022). Instrument supported by digital applications to diagnose the communicative competence of students with ASD: design and validation. *Innoeduca. International Journal of Technology and Educational Innovation*, *8*(2), 83-96. https://doi.org/10.24310/innoeduca.2022.v8i2.14264

Lv, Z., Lloret, J. & Song, H. (2021). Real-time image processing for augmented reality on mobile devices. *Journal of Real-Time Image Processing*, *18*(1), 1-14. https://doi.org/10.1007/s11554-021-01097-9

Madanipour, P., & Cohrssen, C. (2020). Augmented reality as a form of digital technology in early childhood education. *Australasian Journal of Early Childhood*, *45*(1), 5-13. https://doi.org/10.1177/1836939119885311

Mielgo-Conde, I., Seijas-Santos, S., & Grande de Prado, M. (2022). Systematic literature review: Benefits of video games in Primary Education. *Innoeduca. International Journal of Technology and Educational Innovation*, *8*(1), 31-43. https://doi.org/10.24310/innoeduca.2022.v8i1.11144

Mohamed, A. (2021). The impact of educational games on enhancing elementary stage pupils' learning and retention of English vocabulary. *Journal of World Englishes and Educational Practices*, *3*(2), 67-76. https://doi.org/10.32996/jweep.2021.3.2.6

Mohamed, A. (2022). *The effectiveness of using augmented reality applications in developing English vocabulary acquisition and reading comprehension skill for preparatory schools pupils.* [Doctoral thesis, Ain Shams University]. Egypt.

O'Connor, R. E., Beach, K. D., Sanchez, V. M., Kim, J. J., Knight-Teague, K., Orozco, G., & Jones, B. T. (2019). Teaching academic vocabulary to sixth-grade students with disabilities. *Learning Disability Quarterly*, *42*(4), 231-243. https://psycnet.apa.org/doi/10.1177/0731948718821091

Oh, E. (2020). How to prepare pupils for the 4th industrial revolution society. *Studies in Educational Management*, *7*(1), 17-27. https://doi.org/10.32038/sem.2020.07.02

Peterson, R., McGrath, L., Willcutt, E., Keenan, J., Olson, R., & Pennington, B. (2021). How specific are learning disabilities? *Journal of Learning Disabilities*, *54*(6), 466-483. https://doi.org/10.1177/0022219420982981

Pivec, M., & Dziabenko, O. (2004). Game-based learning framework for collaborative learning and student e-teamwork. *E-Mentor*, *2*(1),1-14

Richardson, D. (2016). Exploring the potential of a location based augmented reality game for language learning. *International Journal of Game-Based Learning*, *6*(3), 34–49. https://doi.org/10.4018/IJGBL.2016070103

Rozi, I., Larasati, E., Lestari, V. (2021). *Developing vocabulary card base on augmented reality (AR) for learning English* [Conference Session]. IOP Conference Series: Materials Science and Engineering (1073). https://doi.org/10.1088/1757-899X/1073/1/012061

Sadikin, I. S., & Martyani, E. (2020). Integrating Augmented Reality (AR) In EFL class for teaching vocabulary. *Professional Journal of English Education, 3*(2), 161-167. https://doi.org/10.22460/project.v3i2.p161-167

Santos, M., Lübke, A., Taketomi, T., Yamamoto, G., Rodrigo, M., Sandor, C., Kato, H. (2016). Augmented reality as multimedia: The case for situated vocabulary learning. *Research and Practice in Technology Enhanced Learning*, *11*(1), 1-14. https://doi.org/10.1186/s41039-016-0028-2

Silva, M., Roberto, R., & Teichrieb, V. (2013). Evaluating an educational system based on projective augmented reality. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE) 24*(1), 214-230. http://doi.org/10.5753/cbie.sbie.2013.214

Solak, E. & Cakır, R. (2015). Exploring the effect of materials designed with augmented reality on language learners' vocabulary learning. *The Journal of Educators Online-JEO*, *13*(2), 50-72. https://www.learntechlib.org/p/161393/

Sun, M., Wu, X., Fan, Z., & Dong, L. (2019). Augmented reality based educational design for Cchildren. *International Journal of Emerging Technologies in Learning, 14*(03), 51-60. https://doi.org/10.3991/ijet.v14i03.9757

Thornbury, S. (2002). *How to Teach Vocabulary*. Longman

Tyson, M. (2021). Impact of augmented reality on vocabulary acquisition and retention. *Issues and Trends in Learning Technologies, 9*(1), 1-14. https://doi.org/10.2458/azu_itlt_v9i1_tyson.

VanUitert, V. J., Kennedy, M. J., Romig, J. E., & Carlisle, L. M. (2020). Enhancing science vocabulary knowledge of students with learning disabilities using explicit instruction and multimedia. *Learning Disabilities: A Contemporary Journal*, *18*(1), 3-25.

Wang, S., & Lee, C. (2021). Multimedia gloss presentation: learners' preference and the effects on EFL vocabulary learning and reading comprehension. *Frontiers in psychology*, *11*, 3950. https://doi.org/10.3389/fpsyg.2020.602520

Willoughby, M., Magnus, B., Vernon-Feagans, L., & Blair, C. (2017). Developmental delays in executive function from 3 to 5 years of age predict kindergarten academic readiness. *Journal of Learning Disabilities, 50*(4), 359-372. https://doi.org/10.1177/0022219415619754

Woodeson, K., Limna, P., & Nga-Fa, N. (2023). Students' vocabulary learning difficulties and teachers' strategies: a qualitative case study of Ammartpanichnukul School, Krabi in Thailand. *Advance Knowledge for Executives*, *2*(1), 1-9.

Zhou, X. (2014). Learner's strategy use to guess word meanings during interactive read-aloud: A case study. [Unpublished master's thesis]. University of Stirling.

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Investigation of Chinese undergraduate EFL Learners' Online Communication Strategies

Investigación de las estrategias de comunicación en línea de los estudiantes chinos de inglés como lengua extranjera

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ABSTRACT

With the outbreak of the Covid-19 pandemic, online learning has gained popularity throughout the world in recent years. How EFL learners communicate with their teachers and classmates online has sparked great interest with a view to enhancing their performance in online learning. This study aimed to explore the online communication strategies of Chinese undergraduate EFL learners and how they vary according to gender and English proficiency. The quantitative method was adopted in this study. The participants were 120 undergraduate EFL learners from a public university in China. The questionnaire on online communication strategies, consisting of 30 items, was developed. Cronbach alpha and factor analysis were conducted to evaluate the reliability and validity of the questionnaire. The descriptive statistics and independent T-tests were used for data analysis. The study reached the conclusion that the most commonly used online communication strategies are Reduction strategies, followed by Focus on Form, Social-cultural, Paralinguistic, Compensatory, and Interactional strategies. Male and female learners differed significantly in the use of reduction strategies, focus on form strategies, social-cultural strategies, and paralinguistic strategies. Furthermore, there is a significant difference in the use of all types of online communication strategies between good learners and poor learners, with good learners applying more online communication strategies than poor learners. The study indicates that teachers should raise students' awareness of online communication strategies that are conducive to online communication and learning. Training on online communication strategies should be provided with a view to enhancing students' communication competence as well as English proficiency.

KEYWORDS Online communication strategies; undergraduate EFL learners; gender; language proficiency; inventory of online communication strategies.

RESUMEN

Con el estallido de la pandemia de Covid-19, en los últimos años, el aprendizaje en línea ha ganado popularidad en todo el mundo. La forma en que los estudiantes de inglés como lengua extranjera se comunican con sus profesores y compañeros de clase en línea ha despertado un gran interés con propósito a mejorar su desempeño en el aprendizaje en línea. Este estudio tuvo como objetivo explorar las estrategias de comunicación en línea de los estudiantes chinos de licenciatura en

Inglés como Lengua Extranjera y cómo varían según el género y el dominio del inglés. Para este estudio, se adoptó el método cuantitativo. Los participantes son 120 estudiantes universitarios en Inglés como Lengua Extranjera de una universidad pública en China. Se desarrolló el cuestionario sobre estrategias de comunicación online, compuesto por 30 preguntas. Se aplicaron el análisis factorial y alfa de Cronbach para evaluar la confiabilidad y validez del cuestionario. Para el análisis de los datos se utilizó la estadística descriptiva y la prueba T independiente. El estudio llegó a la conclusión de que las estrategias de comunicación online más utilizadas son las de Reducción, seguidas de las de Enfoque en la Forma, Socioculturales, Paralingüísticas, Compensatorias e Interacciónales. Se concluyó igualmente, que existe una diferencia significativa entre estudiantes masculinos y femeninos en el uso de estrategias de reducción, estrategias de enfoque en la forma, estrategias socioculturales y estrategias paralingüísticas. Agregando además que, existe una diferencia significativa en el uso de todo tipo de estrategias de comunicación en línea, entre los estudiantes diligentes y no tan diligentes. Y de ello se deduce que, los estudiantes diligentes aplican más estrategias de comunicación en línea a diferencia de los no diligentes El estudio indica que los profesores deberían concientizar a los estudiantes sobre las estrategias de comunicación en línea que favorecen la comunicación y el aprendizaje en línea. Se debe proporcionar capacitación sobre estrategias de comunicación en línea con objetivos a mejorar la competencia comunicativa de los estudiantes, así como su dominio del inglés.

PALABRAS CLAVE Estrategias de comunicación en línea; estudiantes universitarios de Inglés como Lengua Extranjera; género; dominio del idioma; inventario de estrategias de comunicación en línea.

1. INTRODUCTION

1.1. Online learning environment

With the advancement of technology and the emergence of the internet, distance education made its debut. It bears a history of almost two centuries (Albrahim, 2020), and this period manifests crucial changes in the way people acquire knowledge and the way they communicate while studying. Numerous forms of communication have been embraced by our society over the years. Among them, online learning has gained popularity since the 1980s. For an extended period, discussions have revolved around integrating technology into education, seeking avenues to incorporate various scientific advancements into the learning environment (Daniela, 2021). Reports indicated an enormous increase in online graduate and undergraduate programs in higher education institutions (Alam et al., 2022; Albrahim, 2020; Castro & Tumibay, 2021), with the rise of rapid movement from traditional face-to-face programs to fully online instruction at the graduate level (Sun et al., 2023). The ongoing crisis triggered by the Covid-19 pandemic has provided an additional impetus for technological advancements, particularly in guaranteeing access to education, a pivotal domain within society. Considering the unstable epidemiological situation around the world, online learning may be prevalent for a long time, and thus, a study of this particular form of education will continue to be relevant in the coming years (Danchikov et al., 2021).

Over recent years, China has issued sequentially several plans to encourage educational development and informatization, such as the “Thirteenth Five-year Plan for National Educational Development” (State Council of China, 2017) “Thirteenth Five-year Plan for Education Informatization” (Ministry of Education of China, 2016) and “Education Informatization 2.0 Action Plan” (Ministry of Education of China, 2018). The

goals of these plans involve: schools are to build a green, safe, and controllable personal space with comprehensive functions and distinctive features for all the teachers and students, facing all levels of education; to establish a sustainable development mechanism for education informatization; to realize full coverage of teachers with teaching apps, students with learning apps, and schools with digital campus apps; to build a comprehensive platform for "Internet + education"; to explore the new mode of talent cultivation and educational service under this "internet +" circumstance; as well as to accelerate the construction of a learning society where every person can learn at any place at any time. It can be seen that great emphasis has been put on the development of online learning or internet technology.

According to Social Constructivism, learners actively contribute to the construction of their knowledge (Schreiber & Valle, 2013), and learning primarily takes place within social and cultural contexts. Assisted by technology-based communications, online learning has moved from the instructional to the constructivist type of education. Many scholars have investigated smart pedagogy in online learning and concluded that many digital tools could enhance effective communication, which was crucial for optimal online learning performance (Daniela, 2021; Luque-Sánchez & Montejo-Gámez, 2023). Therefore, how teachers and students can achieve effective online communication to optimize their learning performance is vitally important. This is where online communication strategies come into play.

1.2. Online communication strategies

The term "communication strategies" (CS) was coined in 1972 by Selinker to describe the strategies or skills EFL learners used to solve problems in communication. Educational communication refers to communication that occurs in the classroom or educational settings, which can be further divided into two subcategories – Verbal (oral and written) and Non-verbal (facial expressions, vocal cues, eye contact, postures, head movement, and mannerisms). The online setting is unique in that it limits the application of non-verbal cues. For example, students may not be able to see each other or sometimes, even the teacher, leading to less eye contact and facial expressions. There is also less physicality, impeding education intimacy between teacher-students and students-students. Also, fewer face-to-face social interactions may hinder communication between the interlocutors (Aljohani & Hanna, 2021; Aziza, 2021). As a result, online communication demands students to apply different CS more proficiently to cope with problems in expressing their ideas for comprehension and acquisition of knowledge via online platforms.

Hung and Higgins (2016) explored how learners employ CS in both text-based and video-based synchronous computer-mediated communication (SCMC) settings and concluded that learners use different strategies in those two environments. They came up with an inventory of CS for SCMC, grouping CS according to their functions and classifying them into six categories: Interactional Strategies, Focus-on-form Strategies, Compensatory Strategies, Sociocultural Strategies, Paralinguistic Strategies and Reduction Strategies (Table 1, the description of each strategy is in Appendix 1). Meanwhile, online platforms offer various models or functions to supplement or enhance the negotiation of meaning, such as font, colour, audio, video, emoticons, images and so on. In the context of this study, how Chinese students use these functions for online communication is still unknown.

TABLE 1. Hung & Higgins's (2016) Classification of Communication Strategies in SCMC

COMMUNICATION STRATEGIES	SUBCATEGORIES
Interactional strategies (To repair or manage conversational discourse)	• Request for clarification • Confirmation check • Comprehension check • Direct request for help • Indirect request for help • Input elicitation strategies • Feigning understanding • Inferential strategies • Framing • Verbal strategy markers • Omission • Time-gaining strategies ...
Compensatory strategies (To solve language problems of expression through manipulating available language knowledge)	• Circumlocution • Approximation • Use of all-purpose words • Literal translation • Self-rephrasing ...
Reduction strategies (To tackle language problems of expression by changing the intended message)	• Message abandonment • Message replacement
Focus on form strategies (To attend to target-like forms)	• Self-correction • Meta-talk • Own accuracy check ...
Sociocultural strategies (To sustain a collaborative and friendly interaction)	• Social formula • Code-switching
Paralinguistic strategies (To solve problems of expression or facilitate language problems and to compensate for the modality restrictions)	• Mime • Use of text or symbols to display the effects of intonation • Use of emoticons • Punctuation • Substitution

1.3. Research problem and need for the study

It is a general consensus that the primary aim of language learning is to cultivate learners' communicative competence (Ahmed & Pawar, 2018b), one of whose key ingredient is strategic competence (Canale & Swain, 1980). Li (2019) announced that new problems were present in teacher-student communication and interaction when classes moved from offline physical space to online virtual space. Bui et al. (2021) investigated the benefits and drawbacks of online EFL learning and reported EFL students' difficulties in interaction and concentration. Guo and Asmawi (2023) also conducted a study on communication between teachers and students during online learning and found that students suffered from isolation and misunderstanding

owing to a lack of nonverbal cues and communication skills or strategies, leading to communication problems Therefore, a good command of online CS can be of great value to these students and improve their quality of online communication.

Research on the use of these strategies has been extensively conducted in face-to-face communication (Ahmad et al., 2022; Ahmed & Pawar, 2018a; Radmehr, 2020; Zhao & Intaraprasert, 2013). However, only a few studies have investigated online CS where there is an apparent lack of nonverbal cues or social interactions that may hinder communication with the interlocutors (Aljohani & Hanna, 2021; Aziza, 2021; Hung & Higgins, 2016; Parcon & Reyes, 2021; Shih, 2014; Smith, 2003). According to Social Information Processing (SIP) Theory, learners with computer-mediated communication rely more on interactive strategies than in face-to-face settings, and they tend to adjust their CS for effective interaction. Thus, it is assumed that the usage of CS in online settings is different from those in face-to-face settings. Exploring effective CS for foreign language learning in online settings is essential to enhance and optimize the performance and quality of online learning.

Previous research on online CS was conducted qualitatively and with fewer participants, focusing on an in-depth analysis of types and reasons for the choice of online CS, and thus, their conclusions varied. For instance, Smith (2003) investigated the link between CS and task types in SCMC, concluding that learners employed diverse CS with an emphasis on discourse, pragmatic, and paralinguistic strategies. The findings revealed that learners whose English proficiency is at an intermediate-low level used more substitution, framing, fillers, and politeness strategies. Non- and para-linguistic cues such as gesture, gaze, and intonation were reported to be absent in CMC, which led to a heavy use of substitution strategy.

Aziza (2021) explored the gender effects on online CS with a qualitative study. The participants were four male and four female Grade Eight students from the English department. Data were collected through online conversations and interviews. Results indicated that fillers, hesitation devices, and gambits were the most frequently used strategies for both genders, while circumlocution was the least. Female students demonstrated a higher frequency of using CS compared to their male counterparts.

Parcon and Reyes (2021) investigated oral CS in online classroom discussions. Recorded classroom discussions and semi-structured interviews were conducted for data collection. They claimed that students used 18 oral CS based on Dornyei and Scott's (1997) classification in online classroom discussions. They also attributed the learners' choice of CS to the following factors: lack of confidence, shortage of linguistic knowledge, speaking anxiety, failure to comprehend ideas, and other external factors.

Gender and language proficiency have been influential yet controversial factors in the choice of CS. Some research indicated that females use more communication strategies than males (Wang, 2008; Zhao & Intaraprasert, 2013), while some studies concluded that male learners apply more strategies than female students (Mahardika et al., 2014; Yaman & Özcan, 2015). Others found no significant difference in the strategies used (Lai, 2010; Kaivanpanah et al., 2012). Likewise, some studies reported significant variance in learners' choice of CS based on their language proficiency (Alawi, 2016; Aziz et al., 2018), while some studies found no relation to their language proficiency (Uztosun & Erten, 2014; Yaman & Özcan, 2015).

It is thus, evident from the above discussion that previous studies focused on a qualitative aspect using different tasks with fewer participants and resulted in inconsistent findings with regard to the areas of study.

Therefore, this study aims to fill the gaps by exploring the CS students often use in online learning from a quantitative aspect and how they vary in gender and language proficiency.

1.4. Research questions

RQ 1: What is the status quo of the use of online communication strategies among Chinese undergraduate EFL learners?

RQ 2: Is there any significant difference in the Chinese undergraduate EFL learners' use of online communication strategies in terms of gender?

RQ 3: Is there any significant difference in the Chinese undergraduate EFL learners' use of online communication strategies in terms of English proficiency?

2. MATERIAL AND METHOD

2.1. Participants

This study adopts a quantitative design to fulfill the research goals and objectives. The random sampling method is adopted with 120 undergraduate students randomly selected from those taking online English courses in a public university. The students were between 18 - 22 years old. The population was from various programs: Architecture, Electronic Communication and Rail Transit. They had online English courses for around 6-8 hours per week from Sept. 2021-Feb.2023. Table 2 manifests their demographic information. English proficiency is measured by the score of the latest final exam. Scores above 80 are good, 60-80 are average, and below 60 are poor.

TABLE 2. Participant demographic information

		NUMBER OF THE STUDENTS	PERCENTAGE OF THE STUDENTS
Gender	Male	56	46.67%
	Female	64	53.33%
Age Group	18-23	120	
English Proficiency	Good > 80	9	7.5%
	Average 60-80	101	84.17%
	Poor < 60	10	8.33%
Language of Instruction	English	120	

2.2. Instrument

A survey instrument was designed based on Hung and Higgins's (2016) Communication Strategy Inventory for SCMC to get the reported frequency of the usage of different online CS. This inventory was relatively newly developed, and was originally targeted at Asian students and SMC, which were of similar background to

those in this study. There are 30 items in total - 8 items for interactional strategies, 3 for reduction strategies, 4 for compensatory strategies, 7 for paralinguistic strategies, 4 for focus on form strategies, and 4 for sociocultural strategies. A Likert-type scale was used for all items on the instrument. Respondents were asked to rate each item against a five-point scale. The proposed responses for the questionnaire are: 1 = Almost never; 2 = Rarely; 3 = Sometimes; 4 = Quite often; 5 = Most of the time.

2.2.1. Reliability of the instrument

Cronbach's alpha was tested to analyze the instrument reliability using SPSS20. The results (Table 3) showed that the whole standardized Cronbach's alpha was 0.970, while the standardized Cronbach's alpha for each construct (Interactional, Compensatory, Reduction, Focus on form strategies, Sociocultural strategies, Paralinguistic) were 0.927, 0.876, 0.836, 0.857, 0.865, 0.918 respectively. All the Cronbach's Alpha were above 0.8, indicating a very high inner consistency of the instrument and that the survey was highly reliable.

TABLE 3. Cronbach's Alpha for the questionnaire

	CRONBACH'S ALPHA	STANDARDIZED CRONBACH'S ALPHA	NUMBER OF ITEMS
Whole	0.970	0.970	30
Interactional strategies	0.926	0.927	8
Compensatory strategies	0.876	0.876	4
Reduction strategies	0.836	0.836	3
Focus on form strategies	0.856	0.857	4
Sociocultural strategies	0.864	0.865	4
Paralinguistic strategies	0.916	0.918	7

2.2.2. Content validity and face validity of the instrument

Content validity is the extent to which the questionnaire accurately and adequately represents the specific content domain it is intended to measure. Face validity is the clarity, difficulty, relevance, and sensitivity of a test to its intended audience (Allen et al., 2023). The survey items were written based on Hung and Higgins's (2016) Inventory of communication strategies and descriptions in the mode of SCMC, with reference to Nakatani's (2006) Oral Communication Strategy Inventory (OCSI). Considering the online environment, which tends to be absent of physical cues such as facial expression, hand gestures or eye contact, factors related to paralinguistic and social-cultural strategies had been modified accordingly based on a thorough review of relevant literature, and comments and feedback from relevant experts and observations by the researchers. Albrahim (2020), Thompson (2020), and other scholars offered some insights into CS in an online learning environment. Table 4 showed a detailed explanation of related strategies and their sources.

TABLE 4. Online communication strategies and their sources

COMMUNICATION STRATEGIES	DESCRIPTION	RESOURCES
Interactional Strategies		
Comprehension Check	I make comprehension checks to ensure the interlocutor understands what I want to say in online learning.	Hung & Higgins, 2016; Nakatani, 2006
Indirect Request for Help	I pause or hesitate to elicit help from the interlocutor in online learning.	Hung & Higgins, 2016
Inferential Strategies	I ask questions or give comments to previous content to see if I understand correctly in online learning.	Hung & Higgins, 2016
Inferential Strategies	I ask questions or give comments to previous content to elicit new information in online learning.	Hung & Higgins, 2016
Framing	I use "first, second, or let's begin" to mark the beginning or transition of the topic in online learning.	Hung & Higgins, 2016
Verbal Strategy Markers	I Use verbal marking phrases such as "you know" or "kind of" to indicate the use of strategy or less accurate form in the target language in online learning.	Hung & Higgins, 2016
Time-gaining Strategies	I Use fillers such as "umm..., I think..." or repeating interlocutor's words to fill pauses in order to maintain conversation at times of thinking in online learning.	Hung & Higgins, 2016
Verbal Strategies	I change my way of saying things according to the context in online learning.	Observation
Compensatory Strategies		
Circumlocution	I give examples or descriptions of the target object or action because I don't know the exact words in online learning.	Hung & Higgins, 2016
Approximation	I use a single substitute term with which the target term shares semantic features in online learning. (eg. I use "fruit" to replace a specific type of fruit "Pomegranate".)	Hung & Higgins, 2016
Use of All- purpose Words	I use "thing, this, that, stuff, do..." to replace specific words that I don't know how to say in online learning.	Hung & Higgins, 2016
Replacement	I use images or emojis to replace words that I don't know how to say in online learning.	Observation
Reduction Strategies		
Message abandonment	I leave a message unfinished because of language deficiency in online learning.	Hung & Higgins, 2016; Nakatani, 2006
Message replacement	I reduce the message and use simple expressions in online learning.	Nakatani, 2006
	I replace the original message with another message because of feeling incapable of executing my original intent in online learning.	Hung & Higgins, 2016;

Focus on form Strategies		
Self-correction	I correct myself when I notice that I have made a mistake in online learning.	Hung & Higgins, 2016; Nakatani, 2006
Own Accuracy Check	I rise my intonation to check if my expression is correct in online learning.	Hung & Higgins, 2016;
	I pay attention to grammar and word order during conversation in online learning.	Nakatani, 2006
	I notice myself using an expression that fits a rule that I have learned in online learning.	Nakatani, 2006
Social-cultural Strategies		
Social Formula	I use fixed patterns for greetings, apologies, and leave-takings, etc., such as "sorry to interrupt you" and "nice to meet you" in online learning.	Hung & Higgins, 2016;
Code-switching	I Use first-language words in the target language speech for purposes such as to show familiarity or to negotiate, such as " litchi (荔枝)" and "typhoon (台风)".	Hung & Higgins, 2016;
Cultural awareness	I respect and consider cultural differences during online communication.	Albrahim, 2020
	I tried to seek out information on an unfamiliar culture before initiating cross-cultural communication.	Thompson, 2020
Paralinguistic Strategies		
Mime	I use gestures and body movements to express a message in online learning.	Hung & Higgins, 2016;
Use of Emoticons	I use emoticons or keyboard symbols to display facial expressions and emotional states in online learning.	Hung & Higgins, 2016;
Punctuation	I use punctuation extensively such as using a question mark to indicate a rising intonation or using it alone to show a confused state, using exclamation to express surprise, or using ellipsis points to indicate the intention to shift turns or topics or to mean "no comment" in online learning.	Hung & Higgins, 2016;
Rhythm and Intonation	I pay attention to my rhythm and intonation when talking online.	Nakatani, 2006
Font, Colors, and Effects	I emphasize the important points using font, colors, and effects in online lessons.	Albrahim, 2020
Images, Pictures, and Graphs	I use images, pictures, and graphs effectively to express my points in online learning.	Observation
Music and Sound Effects	I use music, sound effects, and other resources to emphasize my point in online learning.	Observation

The items were proofread by two professors in this field. They discussed the degree to which each item was representative of a construct's concept and reached a consensus. The content validity was established. The Chinese version was also provided when distributing the survey. The translation was done by the researchers and verified by two Chinese professors in English translation and one American teacher who studied Chinese

for five years. The questionnaire was distributed to six students to test its face validity. A focus group interview was conducted with the students to collect information about whether the items were understandable, relevant and easy to answer. Items were rephrased based on their feedback to improve the face validity.

2.2.3. Construct validity

Structural equation modeling (SEM) is highly useful in assessing intricate theoretical connections among numerous variables, particularly in the realms of social science and second language (L2) studies (Hair & Alamer, 2022). There are two primary methods for structural equation modeling (SEM): covariance-based structural equation modeling (CB-SEM) and partial least squares structural equation modeling (PLS-SEM), which is also known as composite-based structural equation modeling. CB-SEM demands stricter assumptions, such as multivariate normality, and larger sample sizes when employing the maximum likelihood (ML) estimator. In contrast, the PLS estimator operates without assuming data normality by default (Hair & Alamer, 2022). The main reasons for the popularity of PLS-SEM are its capability to estimate very complex models and its relaxed data requirements. PLS-SEM is also effective in providing solutions with smaller sample sizes compared to CB-SEM due to its iterative process. In PLS-SEM, the optimization alternates between refining the measurement model and the structural model until the primary goal of enhancing prediction, rather than model fit, is met (Hair & Alamer, 2022). For CB-SEM, it is recommended to have 300 and above participants to be adequate for factor analysis (Taherdoost et al., 2014), but PLS- SEM can be applied with fewer samples. In addition, Hair et al. (2019) stated, “Researchers should select PLS-SEM when the analysis is concerned with testing a theoretical framework from a prediction perspective; when the structural model is complex and includes many constructs, indicators and/or model relationships”(p. 5). PLS-SEM can be used for confirmatory composite analysis, which is a combination of exploratory and confirmatory analysis to assess the model (Hair et al., 2020). The main analysis is based on total variance, which is an extension of principal components analysis. Considering the above merits, this study used PLS-SEM method.

According to Hair and Alamer (2022), several steps need to be taken to assess the construct validity. First, estimate the loadings and their p-value. Table 6 showed the factor loadings for each item calculated using SmartPLS 4.

TABLE 6. Factor Loading for Each Item

	IS	ComS	RS	FS	SoCS	ParaS
IS9	0.737					
IS12	0.754					
IS15	0.753					
IS16	0.833					
IS17	0.815					
IS18	0.763					
IS19	0.808					
IS20	0.788					

	IS	ComS	RS	FS	SoCS	ParaS
IS12	0.83					
ComS22		0.812				
ComS23		0.794				
ComS24		0.861				
ComS28		0.728				
RS30			0.674			
RS31			0.815			
RS32			0.880			
FS34				0.759		
FS35				0.767		
FS36				0.733		
FS37				0.835		
SoCS39					0.839	
SoCS40					0.790	
SoCS42					0.745	
SoCS43					0.770	
ParaS44						0.732
ParaS45						0.818
ParaS46						0.793
ParaS47						0.787
ParaS48						0.803
ParaS49						0.763
ParaS50						0.796

Note: $P < 0.01$

Factor loading reveals the intensity and direction of the association between each variable and the latent factor(s) identified during factor analysis. It indicates how effectively an item captures the essence of the underlying construct (Vinzi et al., 2010). Hair and Alamer (2022) suggested that a factor loading value exceeding 0.5 is considered acceptable, and when it reaches 0.7, or higher, it is regarded as good for a single indicator. Additionally, it is important to assess the significance of the factor loading estimates. As shown in Table 6, all items except 1 were above 0.7 and the 1 item was between 0.5-0.7, and they were statistically significant at .01.

Second, estimate indicator reliability. Indicator reliability can be gauged by squaring the individual indicator loadings. A value of .50 is deemed satisfactory, suggesting that at least 50% of the variance in a single indicator can be explained by the associated latent variable. This means the factor loading for each item should be above 0.707. In the above table, only one item was below 0.707, but considering the composite reliability and theoretical structure, it was kept for future analysis.

Third, examine construct internal consistency reliability. This is evaluated through Cronbach's alpha (see Table 3) and Composite Reliability (CR) (see Table 7). The commonly accepted cut-off value for both measures is .70 (Hair et al., 2017). However, if the reliability estimate surpasses .95, it suggests that individual items might be redundantly measuring the same aspect of the construct.

Fourth, obtain the average variance extracted (AVE). It assesses the degree to which items within a particular construct exhibit positive correlations and share a significant amount of variance. The rule of thumb dictates that values equal to or greater than .50 indicate convergent validity of the construct. Mathematically, a value of .50 implies that the mean values of the items' factor loadings are .708 or higher, signifying a sufficiently meaningful relationship between the variances of the items and their assumed construct. Table 7 showed the composite reliability and the AVE values.

TABLE 7. Construct Validity of Questionnaire on Online Communication Strategies

CONSTRUCTS	COMPOSITE RELIABILITY (rho_a)	COMPOSITE RELIABILITY (rho_c)	AVERAGE VARIANCE EXTRACTED (AVE)
IS	0.927	0.926	0.612
ComS	0.880	0.877	0.640
RS	0.847	0.835	0.631
FoFS	0.859	0.857	0.600
SoCS	0.868	0.866	0.619
ParaS	0.919	0.918	0.616

From the table above, it can be seen that the average variance extracted for all factors is above 0.5, and the composite reliability is above 0.7, which show that the questionnaire has good construct validity (Hair & Alamer, 2022).

2.3. Data Collection and Analysis

The survey link was sent to relevant students via WeChat with a participant information sheet stating the purpose of the study and their consent was obtained online. There was a statement, "By clicking 'I agree' below, you are indicating that you are at least 18 years old, have read and understood this consent form, and agree to participate in this research study." in the online survey. Those who agreed proceeded to the survey questions. The participants were informed that their participation was completely voluntary. The study was conducted in accordance with the University Research Ethics Guidelines and is approved by the University Research Ethics Committee. It took two weeks to get 123 responses; upon eliminating invalid answers, there were 120 valid responses. Data analysis was carried out using SPSS 20. Descriptive statistics were displayed. The normality of the data was tested, and independent sample T-test was used.

3. RESULTS

In order to answer RQ1: What is the status quo of the use of online communication strategies among undergraduate EFL learners, descriptive statistics were presented in the following Table 8.

TABLE 8. Descriptive Statistics of Online Communication Strategies of Undergraduate Students

DESCRIPTIVE STATISTICS					
	N	Minimum	Maximum	Mean	Std. deviation
IS	120	1.00	5.00	2.8927	.82061
ComS	120	1.00	5.00	3.0542	.88651
RS	120	1.00	5.00	3.2167	.84532
FS	120	1.00	5.00	3.1979	.83067
SoCS	120	1.00	5.00	3.1958	.84340
PS	120	1.00	5.00	3.1821	.84098
N valid	120				

It can be seen from the table that learners used Reduction strategies most frequently, with the highest mean score (3.2167), followed by Focus on Form (mean score 3.1979), Social-cultural (3.1958), Paralinguistic (3.1821), Compensatory (3.0542) and Interactional strategies (2.8927).

In order to answer RQ 2: Is there any significant difference in the Chinese undergraduate EFL learners' use of online communication strategies in terms of gender, Independent Sample T-test was conducted to compare the CS of male and female students. Prior to T-test, the Normality of the data was first tested. Table 9 showed the results and the descriptive statistics of the use of online communication strategies of male and female students.

TABLE 9. The Descriptive Statistics and the Normality of the Data

	Gender	N	Mean	Std. Error Mean	Skewness		Kurtosis	
			Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
IS	Male	56	2.7991	.11310	.273	.319	-.422	.628
	Female	64	2.9746	.09938	.219	.229	.748	.590
ComS	Male	56	2.9643	.13202	.176	.319	-.219	.628
	Female	64	3.1328	.09834	-.040	.299	.597	.590
RS	Male	56	3.0179	.11441	.185	.319	.607	.628
	Female	64	3.3906	.10031	.158	.299	-.270	.590
FS	Male	56	3.0313	.12205	.344	.319	-.077	.628
	Female	64	3.3438	.09090	.170	.299	.109	.590
SoCS	Male	56	3.0179	.12018	.108	.319	.221	.628
	Female	64	3.3516	.09559	-.189	.299	.358	.590
ParaS	Male	56	2.9694	.11951	.516	.319	.166	.628
	Female	64	3.3683	.09373	.223	.299	.446	.590

According to George and Mallery (2010), the values for skewness and kurtosis between +2 and -2 were considered acceptable to prove normal distribution. Meanwhile, Hair et al. (2010) proposed that if skewness was between +2 and -2 and kurtosis was between +7 and -7, it can be interpreted that the data was normally distributed. It can be seen from Table 9 that the Skewness and Kurtosis of each category of strategies were between +1 and -1, which suits the standards aforementioned. Thus it is safe to say that the data to be analyzed is normally distributed. Table 10 displayed the results of the independent T-test.

TABLE 10. Independent Sample T-Test

	T value	P value	Mean Difference	Std. Error Difference
IS	-1.171	.244	-.17550	.14992
ComS	-1.039	.301	-.16853	.16216
RS	-2.461	.015	-.37277	.15149
FS	-2.085	.039	-.31250	.14990
SoCS	-2.197	.030	-.33371	.15190
PS	-2.658	.009	-.39892	.15011

From Table 9, it could be drawn that female students used online CS slightly more frequently than male students, and Table 10 displayed that the P value of reduction strategies, focus on form strategies, social-cultural strategies, and paralinguistic strategies were 0.015, 0.039, 0.030, and 0.009, respectively < 0.05), manifesting that male and female students varied significantly in using all these four strategies.

To answer RQ 3: Is there any significant difference in the Chinese undergraduate EFL learners' use of online communication strategies in terms of English proficiency, another independent Sample T-test was conducted. Prior to T-test, the Normality of the data was first tested. Table 11 showed the results and descriptive statistics of the use of online communication strategies of good and poor students.

TABLE 11. The Descriptive Statistics and the Normality of the Data

	Gender	N	Mean	Std. Error Mean	Skewness		Kurtosis	
			Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
IS	Good	9	3.7639	.28901	.173	.717	-1.462	1.400
	Poor	10	2.0500	.20000	.138	.687	-.148	1.334
ComS	Good	9	3.3611	.37986	.200	.717	-.252	1.400
	Poor	10	2.2500	.27386	-.180	.687	-1.102	1.334
RS	Good	9	3.5185	.23643	1.152	.717	1.354	1.400
	Poor	10	2.3333	.26294	-.698	.687	-.709	1.334
FS	Good	9	3.7778	.30174	.515	.717	-1.664	1.400
	Poor	10	2.3750	.21810	-.575	.687	.173	1.334
SoCS	Good	9	3.9722	.29001	.142	.717	-1.682	1.400
	Poor	10	2.5500	.26562	-.150	.687	.392	1.334
ParaS	Good	9	3.9365	.33001	-.394	.717	-1.082	1.400
	Poor	10	2.5857	.26807	-.047	.687	1.037	1.334

It can be seen that the Skewness and Kurtosis of each category of strategies were between +2 and -2, which can be considered acceptable to prove normal distribution (George & Mallery, 2010). Table 12 displayed the results of the independent T-test.

TABLE 12. Independent Sample T-Test

	T value	P value	Mean Difference	Std. Error Difference
IS	4.960	.000	1.71389	.34553
ComS	2.408	.028	1.11111	.46134
RS	3.322	.004	1.18519	.35672
FS	3.824	.001	1.40278	.36684
SoCS	3.624	.002	1.42222	.39250
PS	3.204	.005	1.35079	.42153

From Table 11, it can be drawn that students with high English proficiency used more online CS than students with low English proficiency. According to Table 12, there is a significant difference in the use of all types of online CS: Interactional ($p=0.000 < 0.05$); Compensatory ($p=0.028 < 0.05$); Reduction ($p=0.004 < 0.05$); Focus on Form ($p=0.001 < 0.05$), Social-cultural strategies ($p=0.002 < 0.05$); and Paralinguistic strategies ($p=0.005 < 0.05$).

4. DISCUSSION

As shown in Table 8, students reported using Reduction strategies most frequently, followed by Focus on Form, Social-cultural, Paralinguistic, Compensatory, and Interactional strategies. The result can be attributed to several reasons: first, the students were non-English majors, and the university in this study was at a lower rank in the country. Therefore, the English proficiency of the students as a whole was wanting. Reduction strategies entail message abandonment and message replacement, which require little effort for explanation or interaction. Thus, it is understandable that students with lower English proficiency are in favor of using these strategies. This result echoes Alawi (2016) and Aziz et al. (2018), who concluded that learners with low proficiency tended to use more reduction strategies while learners who were more proficient in English tended to use more compensatory and interactional strategies. Alawi (2016) posited that learners' insufficient linguistic competence and proficiency often result in the frequent use of reduction strategies due to hesitancy and a tendency to give up easily (Santoso & Mandarani, 2021). Radmehr (2020) also reported that second-language learners might refrain from discussing topics for which they lack the necessary vocabulary or other language skills. Additionally, language learners may initially attempt to engage in conversation on a particular topic but abandon the effort midway upon realizing they lack the necessary language resources to finish their message. Second, Chinese English teachers also prefer focus-on-form instruction in both grammar and vocabulary teaching (Sun & Zhang, 2021). Teachers put great effort in grammar and vocabulary instruction, especially in middle and high school English courses. Thus, it is natural that students focus more on accuracy when they produce English output. This is in line with Santoso and

Mandarani (2021) and Idrus (2016) that learners used a lot of accuracy-oriented strategies to ensure the correctness of their oral English. Third, students have good cultural awareness (Guo & Asmawi, 2023; Zhou, 2022), and they are more proficient with fixed expression patterns, which they acquired at an early stage, such as nice to meet you, excuse me, and sorry to interrupt you. Besides, Chinese students are more respectful, and respect cultural difference, and social courtesy, which result in more frequent use of sociocultural strategies. Fourth, the online environment offers many functions to facilitate communication, including emojis, emoticons, fonts, colors, music, and so on. Students are willing to and familiar with the usage of these functions. This is consistent with Omar et al. (2012) and Shih (2014), who reported that students used paralinguistic strategies in online discussions. According to the New London Group, there are five modes for teaching multiliteracies: linguistic, visual, aural, spatial, and gestural. Apart from the linguistic mode, which emphasize language, other modes are related to paralinguistic strategies. The effective usage of these modes or paralinguistic strategies are beneficial to online communication, which in turn improves online learning performance. Besides, these paralinguistic strategies are also practical in presentations, which is a common task for university students. Last, compensatory and interactional strategies require more effort and language competence from the learners since they encompass strategies such as circumlocution, approximation, paraphrasing, inferential strategies, and request for clarification. It calls for a large quantity of vocabulary and interactions, which might be difficult for learners with limited English proficiency.

The above shows that learners resort to online CS when encountering difficulties in online EFL communication. They commonly use reduction strategies, indicating a lack of motivation in conducting English conversation and implying the learners' low English proficiency. Therefore, teachers should encourage students to use the target language to express themselves, and they can provide explicit training on online CS so that the students can better use these strategies to achieve their communication goals in an online environment.

Gender has been a popular variable in comparing CS, although the research results are often inconsistent. This study indicates that there is a significant difference in terms of gender in the use of online CS of undergraduate EFL students. The results echo Yaman and Özcan (2015), Zhao and Intaraprasert (2013), and Aziza (2021), who concluded that significant differences were found in the use of CS in terms of gender and females used more strategies than their male counterparts. This can be interpreted from the following aspects: men and women assume different social responsibilities and bear different social pressures. They chose different strategies resulting from the division of labor and power in society (Kaivanpanah et al., 2012). Females are more open to expressing themselves and more willing to use paralinguistic strategies to express their attitudes and feelings. Males seem more conservative, preferring simple talk, and tend to shy away from expressing themselves in an online environment (Aziza, 2021).

Language proficiency is believed to be a crucial indicator affecting the choice of CS (Alawi, 2016). This study showed that students with high English proficiency used more online CS than students with low English proficiency. There is a significant difference in the use of all types of online CS. The results are in line with previous studies which concluded that the learners' choice of strategies varied according to their English proficiency. Students with higher proficiency tended to use more CS (An & Wang, 2022; Panggabean & Wardhono, 2017). This may be due to students' motivation. Good students may be more motivated to

grasp opportunities to express themself in English, resulting in more frequent use of CS. It also demonstrates that these students are inclined to employ more interactional and compensatory strategies, whereas those with lower English proficiency are apt to use more reduction strategies. This echoes Huang (2010), cited in Panggabean and Wardhono (2017), that students with higher language proficiency were inclined to utilize linguistic knowledge to express themselves and could choose suitable and effective strategies for communication. On the other hand, those with lower language proficiency tended to depend on knowledge or conceptual-based strategies and employed reduction strategies more frequently. In addition, high-proficiency learners try to get the message across through compensatory and interactional strategies, which are more effective in meaning negotiation and improving linguistic competence. Low-proficiency learners tend to use more reduction strategies, which are less effective in negotiations. Therefore, teachers should guide learners to employ more compensatory strategies rather than reduction strategies with the purpose of promoting learners' online English communication.

5. CONCLUSION

This study aims to explore the online communication strategies used by Chinese undergraduate students in an EFL context. The findings revealed that they used Reduction strategies most frequently, followed by Focus on Form, Social-cultural, Paralinguistic, Compensatory and Interactional strategies. There is a significant difference in the usage of online communication strategies by undergraduate students in terms of gender and language proficiency. Female students employed more of these strategies than their male counterparts, and good learners too applied more online communication strategies than poor learners.

This study offers a reliable and valid tool to assess online communication strategies in an EFL learning context. Second, it provided systematic and comprehensive online communication strategies conducive to effective communication online. It can be seen that various online communication strategies are at the learners' disposal to overcome difficulties in online communication. A good choice in the use of communication strategies among language learners can greatly assist in fostering the development of communicative skills (Garcés & Olivera, 2014). The research indicates that the application of communication strategies enabled students to achieve their communication goals despite having limited linguistic resources. This research may contribute to the instruction of communication strategies in language learning, specifically in teaching EFL. Teachers are advised to introduce communication strategies to their students, teaching and encouraging them to use these strategies appropriately. EFL learners are anticipated to apply communication strategies meaningfully and should also exhibit high motivation to initiate oral communication, enhance participation in interactions, address communication challenges, and effectively achieve communicative goals by conveying accurate messages.

5.1. Limitations and future lines of research

There are certain limitations in this study. Firstly, the sample is not large enough; therefore, future research can use a larger sample to test the validity and reliability of the instrument. Second, this study only used the survey method, so there is a lack of thorough perception of students in terms of their use of online

communication strategies. Thus, future research may use a mixed-mode approach (both survey and interview). Third, future research should focus more on how to develop online communication strategies through various activities or policy implementations.

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7. REFERENCES

Ahmed, S., & Pawar, S. V. (2018a). A study of communication strategies employed by Radfan College EFL students in their classroom interactions. *New Academia: An International Journal of English Language, Literature and Literary Theory, 8*(3), 163-176.

Ahmed, S., & Pawar, S. V. (2018b). Communicative competence in English as a foreign language: Its meaning and the pedagogical considerations for its development. *The Creative Launcher, 2*(6), 267-277.

Ahmad, S. N., Rahmat, N. H., Shahabani, N. S., & Khairuddin, Z. (2022). Discovering The Relationship between Communication Strategies and Fear of Oral Presentation among University Students. *International Journal of Academic Research in Business & Social Sciences, 12*(9), 1185-1212. https://doi.org/10.6007/ijarbss/v12-i9/14859

Alam, M. S., Asmawi, A., Fatema, S., Ullah, M. M., & Azad, M. A. K. (2022). A Local Alternative to Global Wholesale Online Schooling during COVID-19: A Phenomenological Single-Case Study of a Standalone School in Bangladesh. Education Research International. https://doi.org/10.1155/2022/6003710

Alawi, R. A. (2016). Communication strategies used by Omani EFL students. *Pyrex journal of English and literature, 2*(1), 1-11.

Albrahim, F. A. (2020). Online Teaching Skills and Competencies. *TOJET: The Turkish Online Journal of Educational Technology, 19*(1), 9-20.

Aljohani, N. J., & Hanna, B. E. (2021). 'I do not know what's that word in English, but I will tell you about my cousin': EFL learners' communication strategies in online oral discussion tasks. *The Language Learning Journal, 51*(2), 223-237. https://doi.org/10.1080/09571736.2021.1989017

Allen, M. S., Robson, D. A., & Iliescu, D. (2023). Face validity: A critical but ignored component of scale construction in psychological assessment. *European Journal of Psychological Assessment, 39*(3), 153–156. https://doi.org/10.1027/1015-5759/a000777

An, M. & Wang, Y. T. (2022). An Empirical Study on the use of English communication strategies among non-English undergraduate students. *Journal of Minzu Normal University of Xingyi,* (5), 111-118.

Aziz, Z., Fata, I. A., & Balqis, S. (2018). "Wait, How Do I Say that in English?" Communication Strategies for English as a Foreign Language Learners. *Lingua Cultura, 12*(2), 149-154. https://doi.org/10.21512/lc.v12i2.3745

Aziza, M. N. (2021). Gendered perspective on online communication strategies: A case on English department students. In *ELT Forum: Journal of English Language Teaching, 10*(2), 172-184. https://doi.org/10.15294/elt.v10i2.39398

Bui, T. X. T., Ha, Y. N., Nguyen, T. B. U., Nguyen, V. U. T., & Ngo, T. C. T. (2021). A Study on Collaborative Online Learning among EFL Students in Van Lang University (VLU). *AsiaCALL Online Journal, 12*(3), 9-21.

Castro, M. D. B., & Tumibay, G. M. (2021). A literature review: efficacy of online learning courses for higher education institution using meta-analysis. *Education and Information Technologies, 26*(2), 1367-1385. https://doi.org/10.1007/s10639-019-10027-z

Canale, M., and Swain, M. (1980) Theoretical bases of communicative approaches to second language teaching and testing. *Applied Linguistics, 1*, 1-47.

Danchikov, E. A., Prodanova, N. A., Kovalenko, Y. N., & Bondarenko, T. G. (2021). The potential of online learning in modern conditions and its use at different levels of education. *Linguistics and Culture Review, 5*(S1), 578-586. https://doi.org/10.21744/lingcure.v5ns1.1442

Daniela, L. (2021). Smart pedagogy as a driving wheel for technology-enhanced learning. *Technology, Knowledge and Learning, 26*(4), 711-718. https://doi.org/10.1007/s10758-021-09536-z

Dörnyei, Z. & Scott, M. L. (1997). Communication strategies in a second language: Definitions and taxonomies. *Language Learning, 47*(1), 173-210. https://doi.org/10.1111/0023-8333.51997005

Garcés, A. Y. C., & Olivera, S. F. L. (2014). Communication strategies used by pre-service English teachers of different proficiency levels. *How Journal, 21*(1), 10-25. https://doi.org/10.19183/how.21.1.12

George, D. & Mallery, M. (2010). SPSS for Windows Step by Step: A Simple Guide and Reference, 17.0 update (10a ed.). Pearson.

Guo, J., & Asmawi, A. (2023). Exploring Foreign Teachers' Perceptions of Communication with Students in Online Learning in China: A Case Study. *International Journal of Learning, Teaching and Educational Research, 22*(1), 228-246. https://doi.org/10.26803/ijlter.22.1.13

Hair, J., & Alamer, A. (2022). Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language and education research: Guidelines using an applied example. *Research Methods in Applied Linguistics, 1*(3), 100027. https://doi.org/10.1016/j.rmal.2022.100027

Hair, J., Black, W. C., Babin, B.J. & Anderson, R. E. (2010). *Multivariate Data Analysis* (7TH edition). Prentice Hall.

Hair J., Howard, M. C., & Nitzl, C. (2020). Assessing measurement model quality in PLS-SEM using confirmatory composite analysis. *Journal of Business Research, 109*, 101-110. https://doi.org/10.1016/j.jbusres.2019.11.069

Hair, J., Matthews, L. M., Matthews, R. L., & Sarstedt, M. (2017). PLS-SEM or CB-SEM: Updated guidelines on which method to use. *International Journal of Multivariate Data Analysis, 1*(2), 107-123. https://doi.org/10.1504/IJMDA.2017.087624

Hair, J., Risher, J., Sarstedt, M., & Ringle, C. (2019). When to use and how to report the results of PLS-SEM. *European Business Review, 31* (1), 2-24. https://doi.org/10.1108/EBR-11-2018-0203

Huang, C. P. (2010). *Exploring Factors Affecting the Use of Oral Communication Strategies*. In http://www.lhu.edu.tw/accessed January 2022

Hung, Y-W. and Higgins, S. (2016). Learners' use of communication strategies in text-based and video-based synchronous computer-mediated communication environments: opportunities for language learning. *Computer assisted language learning, 29*(5), 901-924. https://doi.org/10.1080/09588221.2015.1074589

Idrus, H. (2016). Enhancing oral presentation skills of ESL students: The use of oral communication strategies. In *Assessment for Learning Within and Beyond the Classroom: Taylor's 8th Teaching and Learning Conference 2015 Proceedings* (pp. 437-446). Springer.

Kaivanpanah, S., Yamouty, P., & Karami, H. (2012). Examining the effects of proficiency, gender, and task type on the use of communication strategies. *Porta Linguarum: revista internacional de didáctica de las lenguas extranjeras*, (17), 79-94. https://doi.org/10.30827/digibug.31960

Lai, H. (2010). Gender Effect on the Use of CSs. *English Language Teaching, 3*(4), 28-32. https://doi.org/10.5539/elt.v3n4p28

Li, Y. (2019). Collaborative online international learning: a pilot study in intercultural communicative competence in Chinese higher education background. *US-China Education Review, 9*(7), 7.

Luque-Sánchez, F., & Montejo-Gámez, J. (2023). A Virtual Escape Room for the Enhancement of Mathematical Communication in Secondary Education. *Technology, Knowledge and Learning*, 1-24. https://doi.org/10.1007/s10758-023-09706-1

Mahardika, P., Sudirman, & Suparman, U. (2014). The effect of gender on communication strategies used by ELT students. *UNILA Journal of English Teaching, 3*(2).

Ministry of Education of China (2016). *Thirteenth Five-year Plan for Education Informatization*. http://www.moe.gov.cn/srcsite/A16/s3342/201606/t20160622_269367.html

Ministry of Education of China (2018). *Education Informatization 2.0 Action Plan*. http://www.moe.gov.cn/srcsite/A16/s3342/201804/t20180425_334188.html?from=timeline&isappinstalled=0

Nakatani, Y. (2006). Developing an oral communication strategy inventory. *The modern language journal, 90*(2), 151-168. https://doi.org/10.1111/j.1540-4781.2006.00390.x

Omar, H., Embi, M. A., & Yunus, M. M. (2012). Learners' use of communication strategies in an online discussion via Facebook. *Procedia-Social and Behavioral Sciences, 64*, 535-544. https://doi.org/10.1016/j.sbspro.2012.11.063

Panggabean, C. I., & Wardhono, A. (2017). Communication strategies used by EFL students in their presentation. *Indonesian EFL Journal: Journal of ELT, Linguistics, and Literature, 3*(2), 39-54.

Parcon, R. E., & Reyes, Z. Q. (2021). Exploring the oral communication strategies used in online classroom discussion. In *ELT Forum: Journal of English Language Teaching 10*(3), 198-211. https://doi.org/10.15294/elt.v10i3.47152

Radmehr, A. (2020). Identifying communication strategies employed by English language learners in private institutes in Sirjan. *Archives of Pharmacy Practice, 1*, 73.

Santoso, D. R., & Mandarani, V. (2021). An Analysis of Communication Strategies Upon Video Blog of English Education Students. *Ethical Lingua: Journal of Language Teaching and Literature, 8*(1), 1-7. https://doi.org/10.30605/25409190.263

Schreiber, L. M., & Valle, B. E. (2013). Social constructivist teaching strategies in the small group classroom. *Small Group Research, 44*(4), 395-411. https://doi.org/10.1177/1046496413488422

Selinker, P. (1972). *Interlanguage. IRAL; International Review of Applied Linguistics in Language Teaching, 10*(3), 209

209-231. https://doi.org/10.1515/iral.1972.10.1-4.209

Shih, Y. C. (2014). Communication strategies in a multimodal virtual communication context. *System, 42*, 34-47. https://doi.org/10.1016/j.system.2013.10.016

Smith, B. (2003). The use of communication strategies in computer-mediated communication. *System, 31*(1), 29-53. https://doi.org/10.1016/S0346-251X(02)00072-6

State Council of China (2017). *Thirteenth Five-year Plan for National Educational Development*. http://www.moe.gov.cn/jyb_xwfb/s6052/moe_838/201701/t20170119_295317.html

Sun, L., Asmawi, A., Dong, H., & Zhang, X. (2023). Empowering Chinese undergraduates' business english writing: Unveiling the efficacy of DingTalk-Aided Problem-based language learning during Covid-19 period. *Education and Information Technologies, 29*(1), 239-271. https://doi.org/10.1007/s10639-023-12288-1

Sun, Q., & Zhang, L. J. (2021). A sociocultural perspective on English-as-a-foreign-language (EFL) teachers' cognitions about form-focused instruction. *Frontiers in Psychology, 12*, 593172. https://doi.org/10.3389/fpsyg.2021.593172

Taherdoost H, Sahibuddin S, Jalaliyoon N (2014) Exploratory factor analysis; concepts and theory. In *Advances in Applied and Pure Mathematics*(pp. 375-382). Mathematics and computers in science and engineering series.

Thompson, J. B. (2020). Mediated interaction in the digital age. *Theory, Culture & Society, 37*(1), 3-28. https://doi.org/10.11606/issn.1982-8160.v12i3p17-44

Uztosun, M., & Erten, İ. (2014). The impact of English proficiency on the use of communication strategies: An interaction-based study in Turkish EFL context. *Journal of Language and Linguistic Studies, 10*(2), 0-182.

Vinzi, V. E., Trinchera, L., & Amato, S. (2010). PLS path modeling: from foundations to recent developments and open issues for model assessment and improvement. In V. Esposito Vinzi, W. Chin, J. Henseler, H. Wan (Eds.) *Handbook of Partial Least Squares* (pp.47-82). Springer.

Wang, L. M. (2008). Gender difference in the learners' use of communication strategies. *Foreign Languages and Their Teaching, 8*, 37-41.

Yaman, Ş., & Özcan, M. (2015). Oral communication strategies used by Turkish students learning English as a foreign language. In M. Pawlak, E. Waniek-Klimczak, (Eds.), *Issues in teaching, learning and testing speaking in a second language* (pp. 143-158). Springer. https://doi.org/10.1007/978-3-642-38339-7_9

Zhao, T. & Intaraprasert, C. (2013). Use of Communication Strategies by Tourism-Oriented EFL Learners in Relation to Gender and Perceived Language Ability. *English Language Teaching, 6*(7), 46-59. https://doi.org/10.5539/elt.v6n7p46

Zhou, J. W. (2022). Research on the Status Quo of Cross-Cultural Communicative Competence of Non-English Majors in Universities for Ethnic Minorities —Taking Aba Teachers University as an Example. C*omparative Study on Cultural Innovation, 25,* 163-166.

Appendix 1. Descriptions of Online Communication strategies

Hung & Higgins's (2016) Classification of Communication Strategies in SCMC

COMMUNICATION STRATEGIES	SUBCATEGORIES	DESCRIPTION
Interactional strategies (To repair or manage conversational dis-course)	• Request for clarification • Confirmation check • Comprehension check • Direct request for help • Indirect request for help • Input elicitation strategies • Feigning understanding • Inferential strategies • Framing • Verbal strategy markers • Omission • Time-gaining strategies • ...	• Seeking clarification on unfamiliar terms or messages. • Repeating in a rising tone to check accuracy; using a first language term, or posing a complete question to confirm understanding. • Asking questions to confirm understanding • Using a direct question to ask for assistance about an unknown knowledge of the target language. Using verbal or nonverbal cues to seek assistance from the interlocutor. • Expressing clearly or signaling to prompt the interlocutor to keep talking. • Faking comprehension of the previous message to sustain the conversation. Posing questions or offering comments based on previous contents to assess one's hypothesis of the prior message, demonstrate the current understanding, or acquire additional information. • Indicating transitions between topics. • Employing verbal markers like "kind of" or "you know" to signal the use of strategies or less precise forms in the target language. • Leaving a blank space for an unknown word and continuing as if it has been said, expecting that the interlocutor can fill the gap based on context. • Utilizing fillers such as "umm..." or repeating the interlocutor's words to fill pauses to sustain the conversation during moments of thinking.
Compensatory strategies (To solve language problems of expression through manipulating available language knowledge)	• Circumlocution • Approximation • Use of all-purpose words • Literal translation • Self-rephrasing • ...	• Providing examples, illustrations, or descriptions of the characteristics of the target object or action. • Using a single substitute term that shares semantic features with the target term. • Utilizing a general "empty" lexical term to replace a specific term, compensating for a lack of vocabulary or to prevent errors. • Translating a first language term literally into a target language term. • Paraphrasing, restructuring, or reiterating one's own statement, occasionally incorporating new information into the repetition.
Reduction strategies (To tackle language problems of expression by changing the intended message)	• Message abandonment • Message replacement	• Leaving a message unfinished due to language difficulties. • Substituting the original message with a new one when feeling incapable of delivering it.

Focus on form strategies (To attend to target-like forms)	• Self-correction • Meta-talk • Own accuracy check ...	• Correct oneself immediately after saying the wrong word or sentence. • Reflecting on one's own or the interlocutor's use of the target language. • Checking the accuracy of one's expression by asking specific questions or repeating a word with a rising intonation (or a question mark in text).
Sociocultural strategies (To sustain a collaborative and friendly interaction)	• Social formula • Code-switching	• Using fixed patterns in language (eg. good morning, sorry to bother you) for social purposes, such as greetings, leave-takings, or apologies. • Incorporating first language words into target language speech for purposes such as displaying familiarity, negotiating, or establishing intersubjectivity.
Paralinguistic strategies (To solve problems of expression or facilitate language problems and to compensate for the modality restrictions)	• Mime • Use of text or symbols to display the effects of intonation • Use of emoticons • Punctuation • Substitution	• Using gestures and body movements to help express intended messages. • Employing capitalization for emphasis (e.g., GREAT) or multiplying letters (e.g., Sooooo good) to convey prolonged sounds. • Using emoticons (e.g., 😃) or keyboard symbols (e.g., ^__^) to express facial expressions and emotional states. • Making extensive use of punctuation, such as using a question mark to indicate a rising intonation, employing exclamation points to express surprise and so on. • Using abbreviated forms of words (e.g., r for are) or phrases (e.g., BTW for by the way) to save typing time or avoid errors.

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A comparative study of the effect of knowledge sharing via Adobe Connect and Google Meet on EFL teachers' creativity

Un estudio comparativo del efecto del intercambio de conocimientos a través de Adobe Connect y Google Meet en la creatividad de los profesores de inglés como lengua extranjera

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ABSTRACT

Information exchange takes place in every community and the advancement of computers and the use of the Internet has made it simpler for people of all communities to communicate information. Teachers also may share personal experiences, information, and communication with their peers in the profession. They can also improve their expertise and skills. As such, the purpose of the present study was to compare the effect of knowledge sharing via Adobe Connect and Google Meet on English as Foreign Language (EFL) teachers' creativity. To do so, 60 EFL teachers from 15 high schools were asked to fill the creativity questionnaire. Then, to find the role of the social platforms on EFL teachers' creativity in their teaching, a week after the treatment, the questionnaire as the posttest was given to the EFL teachers. Next, a semi-structured interview with 20 volunteers sought the Iranian EFL teachers' attitude toward the role of social platforms in their creativity. Overall, the finding indicated that knowledge sharing through Google Meet has more significant effect on EFL teachers' creativity compared to Adobe Connect. In addition, it was found that the teachers agreed with the positive effect of both social platforms on their creativity. The findings have implications for pedagogy as well as further research.

KEYWORDS Adobe Connect; creativity; Google Meet; knowledge sharing.

RESUMEN

El intercambio de información tiene lugar en todas las comunidades y el avance de las computadoras y el uso de Internet ha simplificado la comunicación de información para las personas de todas las comunidades. Los docentes también pueden compartir experiencias personales, información y comunicación con sus pares en la profesión. También pueden mejorar sus conocimientos y habilidades. Como tal, el propósito del presente estudio fue comparar el efecto del intercambio de conocimientos a través de Adobe Connect y Google Meet en la creatividad de los profesores de inglés como lengua extranjera (EFL). Para ello, se pidió a 60 profesores de inglés como lengua extranjera de 15 escuelas secundarias que rellenaran el cuestionario de creatividad. Luego, para encontrar el papel de las plataformas sociales en la creatividad

de los profesores de inglés como lengua extranjera en su enseñanza, dos semanas después del tratamiento, se entregó a los profesores de inglés como prueba posterior el cuestionario. A continuación, una entrevista semiestructurada con 20 voluntarios buscó la actitud de los profesores iraníes de inglés como lengua extranjera hacia el papel de las plataformas sociales en su creatividad. En general, el hallazgo indicó que compartir conocimientos a través de Google Meet tiene un efecto más significativo en la creatividad de los profesores de inglés como lengua extranjera en comparación con Adobe Connect. Además, se encontró que los profesores estaban de acuerdo con el efecto positivo de las plataformas sociales en su creatividad. Los hallazgos tienen implicaciones para la pedagogía y para futuras investigaciones.

PALABRAS CLAVE Adobe Connect; creatividad; Google Meet; intercambio de conocimientos.

1. INTRODUCTION

Every community engages in the process of sharing information. The exchange of information among members of all communities has recently become easier due to the development of computers and the use of the Internet. Teachers can also easily communicate with their professional colleagues, exchange knowledge, and share personal experiences. They can enhance their teaching knowledge and abilities. Teachers are increasingly using social networks as they offer opportunities to gather information, seek feedback, and receive support (Van Den Beemt et al., 2019, p. 8). Employing social networks in academic communications could enhance transparency in academic institutions, accelerate the exchange of information, and foster trust and efficacy within the scholarly community (Bigdeli & Ghanadi Nezhad, 2019).

Teachers' intellectual ability, teaching methods, components, class management, and evaluation knowledge, as suggested by Shih and Lou (2011), are the major topics of such knowledge sharing, with in-service training meetings, school meetings, phone calls, leisure time, and the Internet serving as the mechanisms for sharing of knowledge among teachers. In this sense, the use of communities of practice enhances the sharing of information among instructors by providing chances for members to engage and share best practices (Tseng et al., 2014). As a result, it can be anticipated that teachers' knowledge sharing will have a beneficial impact on their participation in professional practices (Alimirzaee & Ashraf, 2016).

As education in today's schools requires teachers to be high-level knowledge practitioners who constantly advance their professional knowledge, as well as that of their profession, knowledge sharing is linked to relationships among teachers that promote information exchange and teaching (Holste & Fields, 2010). In the current study, knowledge sharing is considered as the provision of knowledge, experiences, skills, and teaching practices to help teachers, collaborate, solve problems, develop new ideas, or implement policies or procedures given the importance of social relationships, interaction, and communication between teachers. For this type of collaboration, it is expected that knowledge sharing among teachers can consequently help them solve a variety of problems related to their teaching practice.

Creativity is another topic that is emphasized in the present study. The idea of creativity is widely recognized as difficult to define and complex and there is no agreement on a precise definition in the literature (Ismayilova & Bolander Laksov, 2022). Boden (2001, p. 95) defines creativity as "the ability to come up with new ideas that are surprising yet intelligible, and also valuable in some way". Beghetto and Kaufman

(2007, p. 1) expands this definition of creativity and notes that it is "the ability to offer new perspectives, generate novel and meaningful ideas, raise new questions, and generate solutions to ill-defined problems". However, it should be noted that teaching for creativity and teaching creatively are two different concepts and the latter which is manifested by features such as nonconformity, flexibility, critical thinking, risk taking and the like (Pashazadeh & Alavinia, 2019) should be more emphasized in educational contexts.

Understanding the creative processes in the classroom relies heavily on teachers' perceptions and attitudes about creativity. Teachers plan their teaching approaches and how they incorporate creativity into the learning process based on their personal ideas. In recent years, there has been an emergence in interest in creativity in the school setting. Creativity is becoming more widely recognized as a necessary component of education (Grigorenko, 2017; Wenjuan, 2023). In this regard, Lin (2011, p. 151) state that "the goal of encouraging creativity through education is to promote the development of creative traits in individuals to address everyday problems, to support their urge for self-actualization, and to strengthen their capacity for future success." In the same line, the researcher argues that the goal of encouraging creativity through education is to "promote the development of creative traits in individuals to address everyday problems, to support their urge for self-actualization, and to strengthen their capacity for future success". Also the creative teaching improves pupils' achievement at the basic level (Schacter et al., 2006). Overall, according to Richards (2013, p. 42), "creative teaching benefits teachers, institutions, and students since it provides a source of continual professional renewal and satisfaction for instructors while also improving the school's quality, efficacy, and reputation".

1.1. Knowledge sharing

The classical economic theory of the organization postulates that people tend to adopt defensive mechanisms when it comes to their personal interests such as power and wealth (Bilginoğlu, 2019; Kim & Mauborgne, 1998). Individuals seem to be reluctant to share their properties, of which knowledge and information are no exceptions, with others in that they view them as materialized assets (Cai & Ma, 2022; Senge, 1997;). As Davenport and Prusak (1998) contended, sharing knowledge willingly with others apparently does not suit human nature. However, when it comes to common interests and goals where people have to interact closely, they sound more willing to share their assets since such joint interactions which accompany the transaction of knowledge and information provide them with intrinsic and extrinsic motives to reinforce their ties. The philosophy behind knowledge sharing has its roots in Vygotsky's (1978) sociocultural theory where learning occurs as a result of the interaction between/among individuals with varying levels of knowledge. From this perspective, knowledge sharing is viewed as an interactional, person-to-person learning activity (Ahmad, 2017; Ahmad et al., 2023).

In EFL education, the dissemination of knowledge and information is also taken for granted. Not only do the foreign language teachers share their knowledge with their learners, but they also need to share their knowledge and expertise with their colleagues. In fact, there are certain degrees of variation among EFL teachers in terms of the knowledge they hold, the teaching methods they employ as well as the degree to which they integrate new knowledge sharing tools into their practice. Once they engage in the dissemination of knowledge, they become familiar with various teaching methods applied in EFL contexts (Alimirzaii & Ashraf, 2016). Another benefit gleaned from the development of sharing of knowledge among EFL teachers

is that based on the litrature "higher education does not operate in isolation... higher education institutions are instituted, managed and run by human beings who themselves have been and are beneficiaries of knowledge sharing" (Adamseged & Hong, 2018, p. 1). In this regard, the role of collaboration and dissemination of knowledge among teachers is highlighted in the literature. For example, based on Runhaar and Sanders (2015) "knowledge sharing is a learning activity with which teachers not only professionalize themselves, but contribute to the professional development of their colleagues as well" (p. 1).

Teachers have an array of platforms at their disposal to share their knowledge and experience including teacher professional development courses, meetings, social media, and conferences. Taking real, face to face knowledge sharing for granted, EFL teachers can also build potentially on virtual platforms such as learning management systems and social media to share their knowledge (Ahmad, 2017). The efficient sharing of knowledge is greatly facilitated by technologies, allowing for quick distribution of news, updates, and changes. Digital content's ability to accommodate different forms of learning makes education more accessible and inclusive due to its multimodal nature. Furthermore, technologies like digital platforms promote resource efficiency, aligning with sustainability goals and supporting environmentally conscious educational practices (Zamiri & Esmaeili, 2024).

1.2. The role of technology in EFL education

Due to the introduction of information and communication technologies (ICT) to the educational context on the one hand and the unprecedented opportunity the Covid-19 pandemic, despite its adverse impacts on the economy and health of people, the long-established person to person pedagogical practices were superseded by an increasing tendency towards more student-centered and digitalized modes of learning (Chen, 2022; Deng & Tavares, 2013). Platforms launched on Web 2.0 protocol such as wikis, e-mails, conferences, LMSs (learning management systems), and social networks like Google Meet cater for virtual learning contexts. Additionally, mobile communication technologies and Internet have already paved the way to the use of social media for educational purposes (Bui et al., 2023; Zhang et al., 2015).

Moreover, such digitalized hi-tech applications have already normalized into the lifestyles of individuals and as the corollary of such normalization they enjoy high levels of acceptance and utilization among people (Nugroho et al., 2021). The integration of technology into the mainstream EFL education can also potentially lead to the students' collaboration as well as autonomy. The synchronous nature of virtual classes, from a constructivist vantage point, entails the interaction among the students, teacher, and the content elements which in itself enhances the opportunities to learn collaboratively. Their asynchronous nature, on the contrary, maximizes the chances of independent, autonomous learning to occur.

As Huang et al. (2023) argued, e-learning technology can be applied to the creation of Digital Knowledge sharing communities which in turn trigger collaboration among teachers and students and expedite personalized learning. Learning and video conferencing applications such as Adobe Connect and Google Meet are among the digital tools that can be used to create digital communities. As Alqahtani and Rajkhan (2020) pointed out, such an approach to online education offers a number of advantages including easy access, flexible and interactive nature, and easy customization. Digital technology such as Adobe Connect and Google

Meet offers a number of practical benefits in advancing and accelerating the dissemination of knowledge, making education more available, and furthering global connectivity (Huang et al., 2023).

Adobe Connect is a software tool designed for distant learning, online meetings, delivering presentations, and sharing desktop. Within Adobe Connect, meeting spaces are divided into 'pods,' each serving a distinct function such as chatting, whiteboarding, or note-taking. Originally a component of the Adobe Acrobat line, Adobe Connect has undergone multiple name changes over time. The web-based nature of the platform is significant as it provides a single web address or URL for accessing and participating in virtual webinars or classroom sessions. Moreover, it includes various integrated features enabling users to deliver PowerPoints, browse websites, or engage in pop quizzes during sessions.

As another online platform, Google Meet, an integrated videoconferencing application with Google Classroom, serves as a tool for synchronous classes. It stands out as one of the most widely utilized videoconferencing applications globally. There's a consistent acknowledgment of Google Meet's role as a digital platform for language learning, facilitating academic interactions between teachers and students (Chandra, 2020; David, 2018). Recent studies highlight the benefits of synchronous learning, allowing learners to actively participate in the learning process (Chandra, 2020). Language instructors find it essential to utilize Google Meet for organizing, delivering, and archiving lectures on the platform.

The dissemination of knowledge in virtual digitalized education is not devoid of challenges. For one thing, the sudden and hasty transition from real, face to face classes to the online classes resulted in a number of concerns to the language teachers especially for those who were not used to applying digital technology into their teaching practices. In reality, this impromptu condition posed serious threats to the creativity of such teachers. In particular, they had to adapt rapidly to the challenges created by the new teaching situation. In fact, many teachers felt they were losing their confidence to teach virtual classes mainly because they were not what the teachers had been educated for. This spoiled their confidence and sense of creativity.

Since emerging technologies may have a positive impact on students' creativity (Li et al., 2022) the successful dissemination of knowledge through Google Meet and Adobe Connect may have such an effect. This is substantiated by the discussion that the most important effect of knowledge sharing, among the other benefits, is related to innovation and creativity "because knowledge sharing does not only mean effective transfer of knowledge, skills, and information, but it also indicates the creation of new knowledge and innovative ideas" (Lee, 2018, p. 3). Similarly, it has been argued that those who actively take part in sharing knowledge, "are more likely to generate, promote, and/or implement innovative ideas in the future" (Wang, 2023, p. 3). Besides, previous investigations have failed to consider the effect of knowledge sharing via Adobe Connect and Google Meet on EFL teachers' creativity. Therefore, it sounds incumbent to examine the impact of EFL teachers' knowledge sharing via Adobe Connect and Google Meet on their creativity. As such, the following research questions were proposed:

1. Compared to Adobe Connect, does GM have a significant effect on EFL teachers' creativity?

2. What is the Iranian EFL teachers' attitude towards the effect of social platforms on their creativity?

2. MATERIAL AND METHOD

2.1. Participants

The participants of this study were selected from Iranian EFL teachers. To conduct the study, 60 EFL teachers from 15 high schools in Kermanshah city, a city in West of Iran, majoring in Teaching English as Foreign Language (TEFL) were recruited. They were selected through available sampling. The teachers' experience ranged from three to 15 years, and their ages ranged between 27 and 52 years. They graduated from different Iranian state and Islamic Azad Universities, with educational levels of B.A., M.A. in TEFL, and English Literature.

The participants were randomly assigned to one Control group (n=18) and two experimental groups including Adobe connect group (n=20) and Google Meet group (n=21). Regarding the years of experience, all the teachers had more than four years of experience. Participants included 24 (53%) female and 36 (47%) male. The statistical population of the study showed that a total of 60 participants 25 (41.6%) hold bachelor's degrees, and 35 (58.4%) hold master's degrees.

2.2. Design

The aim of this study is to compare the effect of knowledge sharing via Adobe Connect and GM on EFL teachers' creativity. Accordingly, the suitable design is quasi experimental design. To do this study three groups were needed:

Control group: Control group that shares knowledge in face to face interactions.

Experimental group 1: Adobe Connect group that uses the platform to share knowledge.

Experimental group 2: Google Meet group that uses the platform to share knowledge.

2.3. Instruments

In total, two instruments were utilized in the study, namely, the EFL creativity questionnaire and a semi-structured interview.

The EFL creativity questionnaire: To assess the EFL teachers' creativity, the scale developed by Khany and Boghayeri (2014) was employed in the present study. There were 43 items with three subscales and a two-point Likert scale. The subscales included seventeen individual difference items, twenty expertise items, and six management items. As reported by the authors, Cronbach's alpha coefficient was used to evaluate the reliability of the questionnaires. The results showed that Cronbach's alpha of the EFL teachers' creativity questionnaire (43 questions) was 0.768 which indicated the appropriate reliability of research tools. The report of the validity of the scale is also presented by the authors.

A semi-structured interview: To find the effect of social platforms on EFL teachers' creativity in their daily practice, a week after the treatment, a semi-structured interview (Appendix) with 15 volunteer EFL teachers from the experimental groups was carried out. There were 5 questions in the interview.

To ensure the content validity of the questions, two TEFL experts reviewed them and provided their comments. The interviews were conducted in Farsi to let the teachers express themselves freely in their first language. Each interview lasted for 15 minutes. The interviewees were asked if they share ideas regarding the latest theories of language teaching in EFL context and if the answer is positive, how they do it and what hurdles they may encounter. The interviewees' responses were recorded, transcribed, and translated to English.

2.4. Procedure

First, the available participants were divided into three groups. The first group as the control group included 18 EFL teachers who did not receive the treatment. The second group was the first experimental group and included 20 EFL teachers who shared their ideas via Adobe Connect. The third group was the second experimental group, it included 21 EFL teachers who shared their opinion via Google Meet. The participants were informed that the data only be used for research and would be kept entirely confidential. Prior to gathering the data, the first researcher explained briefly to the teachers the purpose of the study and then obtained each individual's consent. They were also told in detail what they were required to do. The participants were also reminded that there were no right or wrong answers to the items of the questionnaire. They were also told that the accuracy of the results depended on how honest they could be. Next, during their break time, the creativity questionnaire was given to the participants as the pre-test. They had 20 minutes time to fill in the questionnaire.

As the third step, the important recent theories in TEFL were shared via the Telegram group for all three groups and each teacher was required to choose two theories in English language teaching, read and analyze them critically. The theories in TEFL were employed as part of the treatment since it was thought that classroom discussions offer an excellent platform for nurturing creative thinking abilities. More specifically, it was assumed that by promoting and acknowledging their innovative ideas and distinct viewpoints the participants' creative thinking was fostered (Sternberg & Grigorenko, 2004). The first researcher/the teacher asked each participant of the three groups to select a particular incident that caught their attention and talk about it in the discussion group. The condition in both online discussion and face to face sessions was the same. Each session took around 1.30 hours and lasted two weeks. When there was no volunteer to begin the discussion, the first researcher chose the teacher and asked her about her experience. As the fourth step, the researcher presented a topic and asked a thought provoking question. Teachers were free to express their ideas. It should be noted that all participants were free to voice their concerns or offer their opinions regarding the event. A week after the treatment, all the participants were given the EFL creativity questionnaire again. As the last step, four days after the treatment, a semi-structured interview with 15 volunteer EFL teachers from the experimental groups was carried out. The interviews were conducted in Farsi to let the teachers express themselves freely in their first language. Each interview lasted for 15 minutes. The comments of the respondents were taped, written down, and then translated into English. A summary of the procedure is presented in Table 1.

TABLE 1. The summary of the procedure

STEP	DESCRIPTION
Step 1	The creativity questionnaire was given to the participants.
Step 2	Recent theories in TEFL were shared via the Telegram group for all three groups.
Step 3	Each participant of the three groups was asked to select a particular and talk about it in the discussion group.
Step 4	The participants were presented a topic and were required to ask a thought provoking question.
Step 5	The participants were given the EFL creativity questionnaire again.
Step 6	The interviews were conducted.

3. RESULTS

Calculating the normality of data is essential for many statistical tests because normal data is an underlying assumption in parametric testing. Hence, the Kolmogorov-Smirnov test was used to see if the data in this study was normal. Table 2 examines the distribution of data by the normality test (Kolmogorov-Smirnov test) for three "Control" and "Experimental1" & "Experimental2" groups.

Assumption of Normality Test
H_0: Sig.≥0.5 ; Data distribution is normal.
H_1: Sig.<0.5 ; Data distribution is not normal.

TABLE 2. Results of normality test for the creativity

Groups		Groups	Kolmogorov-Smirnov[a]		N	Items
			Statistic	Sig.		
Pre-test	Creativity	Ctrl	.176	.146	18	43
		Exp1	.070	.120	20	
		Exp2	.087	.090	21	
		Total	**.076**	**.200**	**59**	
Post-test	Creativity	Ctrl	.130	.200	18	43
		Exp1	.059	.113	20	
		Exp2	.098	.080	21	
		Total	**.052**	**.200**	**59**	

As shown in Table 2, the results of the Kolmogorov-Smirnov test proved that all significance values in the three "Control" and "Experimental1" & "Experimental2" groups for research variable are more than 0.05 (Sig.>.05). Due to the fact that the significance values for the normality test were significantly more than the predetermined 0.05, it can be claimed that the data collected from the test had normal distributions.

The first research question inquired which group (control, Adobe Connect or Google Meet) has a significant effect on EFL teachers' creativity a pretest in terms of creativity was given to EFL teachers in three "Control" and "Experimental1" & "Experimental2" groups. A One-Way ANOVA was used to confirm the homogeneity of three groups (Ctrl, Exp1, & Exp2) at the beginning of the research. The descriptive results of the pretest scores are shown in Table 3.

Assumption of One-Way ANOVA Test
H_0: Sig.≥0.5 ; $\mu_1=\mu_2=\mu_3$
H_1: Sig.<0.5 ; $\mu_1\neq\mu_2\neq\mu_3$

TABLE 3. Descriptive statistics of creativity in control and experimental groups in terms of homogeneity in pretest

		Sum of Squares	df	Mean Square	F	Sig.
Pretest	Between Groups	.000	2	.000	.122	.886
	Within Groups	.094	56	.002		
	Total	**.094**	**58**			

According to the obtained results in Table 3, the significant value of the analysis of the variance test for the creativity variable is greater than 0.05, so the H0 hypothesis cannot be rejected, and the result suggests that the three groups were homogeneous in terms of creativity. This means that no significant difference was observed between groups in the pretest. In the following, the research questions will be examined.

Next, in the post-test in three "Control" and "Experimental1" & "Experimental2" groups the creativity of the three groups was compared by a One-Way ANOVA test. The descriptive results of the posttest scores are shown in Table 4.

TABLE 4. Descriptive statistics of creativity in control and experimental groups in posttest

		Sum of Squares	df	Mean Square	F	Sig.
Posttest	Between Groups	.718	2	.359	112.942	.000
	Within Groups	.178	56	.003		
	Total	**.896**	**58**			

According to the obtained results in Table 4, the significant value of the analysis of the variance test is lower than 0.05, so the H1 hypothesis cannot be rejected, and the result suggests that the three groups were different in terms of creativity. It means that a significant difference was observed between groups in the posttest. In the following, in order to examine this question in more detail, MANOVA was used.

Before carrying out covariance analysis, the condition of non-interaction between the independent variable (group) and covariate (pre-test) with the dependent variable (post-test) should be checked. In fact, this was done to check the same slope of the regression line. Also, in this type of analysis, the assumptions of Levin's test for the homogeneity of the variance of the two groups should be observed in the post-test stage, so that the results can be confirmed and the covariance analysis can be performed. The results are shown in Tables 5 to 7.

Presuppositions of analysis of covariance test

1. Examining homogeneity of Variance

Assumption of Levene's Test
H_0: Sig.≥0.5 ; The error variances of the groups are equal
H_1: Sig.<0.5 ; The error variances of the groups are not equal

TABLE 5. The Results of Levene's Test in examining the assumption of equality of variances for the creativity

F	df1	df2	Sig.
.569	2	56	.569

According to the results of Table 5, since sig. was more than 0.05, the null hypothesis is accepted and this means that the variances of the errors in all variables are equal.

2. Examining the homogeneity condition of the slope of the regression line

Assumption of Interaction Test
H_0: Sig.≥0.5 ; The slopes of the regression line are homogeneous
H_1: Sig.<0.5 ; The slopes of the regression line are not homogeneous

TABLE 6. Interaction test between the independent variable (Group) and covariate (Pre-Test) with the dependent variable (Post-Test) of creativity

Dependent Variable	Source of changes	Type III Sum of Squares	df	Mean Square	F	Sig.
Groups * Q.Pre	The interaction effect of pre-test and group	.001	2	.000	.125	.883

According to the results of Table 6, it can be seen that for the creativity variable, the value of the interaction test statistic between the pre-test and post-test groups is not statistically significant, because the significance level is greater than 0.05 standard error. Therefore, the condition of balance of regression slopes for covariance analysis is established.

3. Examining the question

Assumption of Multivariate Test
H_0: Sig.≥0.5 ; Multivariate covariance is not statistically significant
H_1: Sig.<0.5 ; Multivariate covariance is statistically significant

TABLE 7. The results of the analysis of covariance comparing groups in terms of creativity in the Post-Test by controlling the effect of the pre-test

Dependent Variable	Source of changes	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Creativity	Pre-test effect	.035	1	.035	12.686	.001	.187
	Independent variable effect (Group)	.699	2	.350	125.039	.000	.820

As can be seen in Table 7, the value of the test statistic for creativity in the post-test stage has become significant at the 5% error level, because its significance level is less than 0.05 standard error. Therefore, after the training in the three control and experimental groups, in the post-test stage, after removing the effect of the pre-test, there is a significant difference in this variable. The amount of this effect according to the eta squared column was (82) percent. These are the general results of covariance analysis on the data set. In order to check the trend in each of the groups, pay attention to the results in Table 8.

TABLE 8. The Results of the analysis of covariance comparing groups in terms of creativity in the post-test by controlling the effect of the pre-test separately for each group

Dependent Variable	Source of changes	Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Creativity	Ctrl	.004	1	.004	2.371	.143	.129
	Exp1	.025	1	.025	4.621	.050	.204
	Exp2	.010	1	.010	6.941	.016	.268

As can be seen in Table 8, the progress of creativity has become statistically significant only in the experimental group, while in the experimental1 group, progress has also been seen, but it is not statistically significant. The amount of this improvement is also expressed according to the eta square column was 27 percent.

The second research question inquired Iranian EFL teachers' attitude toward the role of social platforms on their creativity. To answer the question a semi-structured interview was employed. To do this, three questions were designed by the researchers. To enable the teachers to speak freely in their own tongues, the interviews were conducted in Persian 15 minutes were allotted for each interview. The interviewees' remarks were recorded, transcribed, and then translated into English.

When asked about the effect of social media on teachers' creativity, one of the interviewees noted that:

"Like all other teaching methods, media should be used sparingly during the educational process. Media can be used to connect ideas or encourage conversation. Social media use in education appears to improve teacher performance as evidenced by the strong effects that knowledge sharing, creativity, cooperation, and engagement have on teachers' performance».

Another teacher also stated that:

"Social media improves cooperation, interaction, learning outcomes, and other course-related qualities that boost teachers' performance both formally and informally. Their comprehension and communication abilities in relation to their job and work profile will grow as a result. All these can result in the teacher's creativity."

In answer to the question that probed the advantages of using social media as a learning tool, a teacher explained that:

"Using media to teach people engages them, helps them retain knowledge, inspires interest in the material, and shows the applicability of numerous ideas. But that is not the case. Social media appears to have impacted how children are taught and learn if we consider the fact that a significant portion of internet users are both students and teachers. Bridges are built between students' prior knowledge and the course's learning objectives through effective instruction."

Another interviewee said that:

"Users can learn a lot online through social media. The analysis of social media has changed everyone's life. Social media use in the education sector will benefit students by enabling them to learn and access information globally. Social media also assists in improving teachers' academic performance and expanding their knowledge through data and information gathering. It provides more options for sharing knowledge and expertise in a fun and interesting way. The best thing about social media is how quickly you can identify the subject and field experts. In order to gain more knowledge and beneficial information from them. It's a great chance for us to seek advice from professionals on the subjects where we might need it."

The interviewees were asked about the best social media for teachers. Eight Interviewees said that they preferred Google Meet. One of them argued that:

> "Google Meet is superior to other social media for learning for a number of reasons. One reason is that the Standard Google Meet is always free as such more preferable compared to other learning management systems (LMSs), which are expensive to buy. Google Meet is also equipped with useful remote teaching functions, allowing you and to learn online easily".

Four other interviewees from this group noted that with the recent change from Google Hangouts to Google Meet, it is thought that Google Meet competes better with Skype and Zoom and is one of the best tools for group videoconferencing. In addition, as they reported, after years of using Google they think that they are more familiar with tools created by Google.

Overall, the results demonstrate that teachers considered Google Meet to be user-friendly, easy to use, and adaptive for interaction. The study confirmed that language instructors perceived it as an effective tool for creativity in language teaching. This is in accordance with the concrete theory which maintains that social interaction is crucial in learning to stimulate and enhance learner development and creativity (Li et al., 2022).

4. DISCUSSION

The present study aimed to compare the effectiveness of knowledge sharing via Adobe connect and Google Meet on EFL teachers' creativity. It was found that the Google Meet group outperformed the Adobe Connect group and that knowledge sharing improved the creativity of the EFL teachers. The result is consistent with research by Parhamnia and Farahian (2021) who found that there was a significant relationship between knowledge sharing and EFL teachers' creativity. Mazhar and Akhtar (2018) investigated the connection between university professors' creativity and knowledge management. As reported, technology, creativity, and knowledge management have significant relationships. Another study came to the conclusion that creativity may be influenced by the combination of new and old knowledge (Kogut & Zander, 1992). It is conceivable that the mutual learning that could result in the generation of new information enhances people's capacity to devise original responses to problems (Kogut & Zander, 1992; Tsai & Ghoshal, 1998). In another study, Ipe (2004) found that developing informal connections with team members' aids in a person's knowledge construction. The results also suggest that social media boosts participants' motivation, which has an impact on their capacity for interactive learning.

As to the comparison of the performance of the Google Meet and Adobe Connect, it has been reported that Adobe Connect and Google Meet softwares have some similar qualities such as customer support, Google Meet has some advantages over Adobe Connect including its functionality, and ease of use, (Software Advise, n.d.) In addition, as reported by the interviewees, the better performance of Google Meet can be explained by its affordability, its useful remote teaching functions, and most importantly higher familiarity of the teachers with Google Meet compared to Adobe Connect.

According to the interviewees' reports in response to the second study question, it was discovered that most respondents had a favorable opinion on the use of social media in education. To advance their professional development, EFL teachers appear to need to work together more. In this case, social media can

be a significant tool for teachers to use in order to share ideas, benefit from one another's knowledge, and ultimately learn more about education.

According to (Al-Fadda & Al-Yahya, 2010), it may be inferred from the study's discussion of social media's role in teacher education that Google Meet might help EFL teachers share knowledge and foster their creativity. According to the research findings, EFL teachers have favorable opinions about using social media (Al-Fadda & Al-Yahya, 2010). Teachers believe that social networking can aid individuals in expanding their knowledge (Bani-Hani et al., 2014). Additionally, teachers think that social media enhances their academic performance and boosts their linguistic self-assurance. They concur that social media can increase their motivation to study (Jethro et al., 2012; Ziegler, 2007). Last but not least, teachers believe that learning through social media is more collaborative than traditional learning and that doing so can help them integrate more successfully into the classroom (Ferdig, 2007).

The findings corroborate Lewandoski's (2015) assertion that the use of Google Meet makes learning more organized and understandable. In the same vein, Lander (2014) explains that the use of Google Meet accomplishes predetermined lesson objectives when utilized cooperatively. The outcomes in terms of collaborative learning were comparable and concur with Ramli et al. (2022) findings who showed that the use of Google Meet promotes collaborative learning and offers language learners a sense of belonging by immersing them in the language community. This demonstrated how useful Google Meet was as a language learning aid in an online distance learning setting. The findings mentioned above concur with that of Lee (2018) which contends that Google Meet is user-friendly and simple to use in the classroom (Lewandoski, 2015), though it is important to note that this may change depending on the context. In line to the conclusions and findings of the study, the comparable studies by Lander (2014) and Isaacson (2013) asserted that Google Meet was adaptable and effective for carrying out learning. Other studies (Lander, 2014; Lewandoski, 2015; Martinez-Nunez et al., 2016) support the findings above, and indicate that Google Meet is efficient for online classroom assignments.

5. CONCLUSIONS

According to the study's findings, teachers' information sharing is becoming increasingly important due to the fast-paced change in knowledge in the age of changing knowledge and the encouragement of teachers' professional development. Through ongoing learning, teachers must adapt to the shifting social norms and educational regulations. Despite this, teachers frequently feel helpless and eager to learn new technology, new teaching methods, and new challenges outside the usual teaching chores and supporting schools in administrative tasks due to a lack of time and space.

Teachers must work together to enhance their daily practice. A school can set up systems for information sharing, allow for more time for professional conversation and discussion, motivate and direct teachers working with various fields of study or grade levels to share their own teaching methods and evaluations and provide knowledge delivery through virtual and actual expertise communities. Knowledge should be shared and expanded so that it does not become less valuable over time. Individually created lesson plans and learning worksheets can be placed on a platform and shared with others to spread knowledge. In order

to develop new teaching models that are appropriate for school pupils and progress teaching techniques in lessons to promote teacher efficacy, teachers could create fresh inspiration and new knowledge through unique knowledge sharing.

This study clarifies how social media may be used to spark teachers' creativity, therefore we propose that Google Meet can encourage information exchange and potentially even advance teachers' professional development. The study also confirmed that teachers evaluated the use of Google Meet as a language learning tool that stimulated collaborative learning, increased creativity in language instruction, and improved understanding of lessons. Our findings clearly show that teachers thought using Google Meet was user-friendly, simple to use, and adaptable for interaction. According to the concrete theory, which maintains that social interaction is crucial in learning to stimulate and enhance learner development during the lesson, the use of Google Meet made lessons clear and understandable, and the study confirmed that language instructors perceived it as an effective tool for language teaching and learning as it bridges the distance created by online distant learning.

Future research can examine if Google Meet usage enhances other facets of teachers' professional development. The results of the present study may also prompt a reevaluation of social media's potential to foster motivation, transparency, and feedback in communication while simultaneously serving as a catalyst for reforming the teacher education system. Such claims can be investigated in the future studies.

The results of the present study might have some implications. Firstly, the education policies and programs should attach more significance to knowledge sharing practice, present proper opportunities for them to increase their knowledge and creativity, and raise teachers' awareness about the significant role of knowledge sharing in EFL education. Secondly, the EFL policymakers could investigate the effectiveness of social media in knowledge sharing among instructors. Thirdly, it is important to investigate the EFL teachers' issues to identify the barriers to creative practices of EFL instructors. Finally, schools as educational institutes should provide a more friendly environment and atmosphere for their teachers to reflect their creative practices in the classroom. The present study had also some implications for academics. The managers should support their EFL instructors financially and consider rewards for them to devote more time to their profession and do their teaching more creatively. Besides, curriculum and syllabus designers, and material developers, should attempt to design lessons, tasks, and practices that encourage creativity in educational system among teachers and students.

5.1. Limitations and future lines of research

The present study has some limitations like any other study. As the first limitation, the sample was not large enough and thus, no generalizable conclusion could be drawn from the results. The second limitation was that available EFL teachers were recruited and this may have affected the outcomes since the chosen samples might have contained talented teachers who were not drawn at random from Iranian EFL teachers. Second, the sampling for this research consisted solely of high schools.

There are some suggestions for future researchers regarding the barriers to sharing knowledge. In further studies, researchers could use larger samples for furthering the understanding of the barriers of sharing

knowledge among EFL instructors. It is also possible for future researchers to consider creative teaching in EFL courses for developing language knowledge and skills and study the instructors' ideas regarding the barriers to creative teaching in EFL courses. Conducting a qualitative research using interviews is another suggestion for future researchers. They could conduct interviews with EFL instructors and EFL learners to find out their perspectives regarding creativity in the classroom and its barriers. It is also needed to conduct some studies to recognize the factors that encourage or hinder EFL instructors from creative teaching.

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7. REFERENCES

Adamseged H.Y., & Hong, J.J. (2018). Knowledge sharing among university faculty members. *Journal of Education and Practice, 9* (24), 1-10.

Ahmad, F. (2017). Knowledge sharing in a non-native language context: Challenges and strategies. *Journal of Information Science, 44*(2), 1-17.

Ahmad, A., Alam, M.S., Kirmani, M.D., & Madsen, D.O. (2023). Why do academicians share knowledge? A study of higher education institutions in India. *Educational Psychology, 14*, 1-13. https://doi.org/10.3389/fpsyg.2023.1181030

Al-Fadda, H., & Al-Yahya, M. (2 01 0). Using weblogs as a tool to encourage pre –class reading, post- class reflections and collaboration in higher education. *US-China Education Review, 7* (7), 100 -106.

Alimirzaii, H. & Ashraf, H. (2016). On the effect of online peer knowledge sharing on Iranian EFL Teachers' professional development. *Theory and Practice in Language Studies, 6*, 134-146. http://dx.doi.org/10.17507/tpls.0601.18

Alqahtani, A. Y., Rajkhan, A. A. (2020). E-learning critical success factors during the covid-19 pandemic: a comprehensive analysis of e-learning managerial perspectives. *Educational Sciences, 10*(9), 216-232. https://doi.org/10.3390/educsci10090216

Bani-Hani, N., Al-Sobh, M., & Abu-Melhim, A. (2014). Utilizing Facebook groups in teaching writing: Jordanian EFL students' perceptions and attitudes. *International Journal of English Linguistics, 4*(5), 27–34. https://doi.org/10.5539/ijel.v4n5p27

Beghetto, D., & J. Kaufman (2007). Toward a broader concept of creativity: A case for mini-C creativity. *Psychology of Aesthetics, Creativity, and the Arts, 1*(2), 73-79. https://doi.org/10.1037/1931-3896.1.2.73

Bilginoğlu, E. (2019). Knowledge hoarding: A literature review. *Management Science Letters, 9*,61-72.

Bigdeli, Z. and Ghanadi Nezhad, F. (2019). Analysis of Iranian faculty information sharing in social networks: the case of Shahid Chamran University. *Journal of Studies in Library and Information Science, 25*, 26, 1-12. https://doi.org/10.22055/slis.2019.14849

Boden, M. A. (2001). Creativity and knowledge. In A. Craft, B. Jeffrey, & M. Leibling (Eds.), *Creativity in education* (pp. 95–103). Continuum.

Bui HP, Ulla MB, Tarrayo VN, Pham CT. (2023). Editorial: The roles of social media in education: affective, behavioral, and cognitive dimensions. *Front Psychol*. doi: https://doi.org/10.3389/fpsyg.2023.1287728

Cai, R.,& Ma, Y. (2022). Why do academicians share knowledge? A study of higher education institutions in India. *Educational Psychology, 14*, 1181030 https://doi.org/10.3389/fpsyg.2023.1181030

Chandra, Y. (2020). Online education during COVID-19: perception of academic stress and emotional intelligence coping strategies among college students. *Asian Education and Development Studies, 10* (2), pp. 229-238. https://doi.org/10.1108/AEDS-05-2020-0097

Chen, M. (2022). Digital affordances and teacher agency in the context of teaching Chinese as a second language during COVID-19. *System, 105*, 102710. https://doi.org/10.1016/j.system.2021.102710

Davenport, T. H., & L. Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Harvard Business School Press.

David, A.T. (2018). *Synchronous learning Vs asynchronous learning in online education*. The Best Schools. http://thebestschools.org/magazines/synchronous vs asynchronous education/

Deng, L., & Tavares, N. J. (2013). From Moodle to Facebook: Exploring students' motivation and experiences in online communities. *Computers & Education, 68*, 167-176. https://doi.org/10.1016/j.compedu.2013.04.028

Ferdig, R. E. (2007). Editorial: Examining social software in teacher. *Journal of Technology & Teacher Education, 15*(1), 5-10.

Grigorenko, E.L. (2017). Creativity and the genome: The state of affairs. *Creative Behavior, 51* (4), 327-329. https://doi.org/10.1002/jocb.201

Holste, J. S., & Fields, D. (2010). Trust and tacit knowledge sharing and use. *Journal of Knowledge Management, 14*(1), 128-140. https://doi.org/10.1108/13673271011015615

Huang, X., Li, h., Huang, L., & Jiang, T. (2023). Research on the development and innovation of online education based on digital knowledge sharing community. *BMC Psychology, 11*, 295. https://doi.org/10.1186/s40359-023-01337-6

Ipe, M. (2004, 3-7 March). *Knowledge sharing in organizations: An analysis of motivators and inhibitors.* Proceedings of Academy of Human Resource Development International Conference (AHRD), Austin.

Isaacson, K. (2013). An investigation into the affordances of Google hangouts for possible use in synchronous online learning environments. *World Conference on Educational Multimedia, Hypermedia and Telecommunications, 1*, 2461-2465.

Ismayilova, K., & Bolander Laksov, K. (2022). Teaching Creatively in Higher Education: The Roles of Personal Attributes and Environment. *Scandinavian Journal of Educational Research, 67*(4), 536–548. https://doi.org/10.1080/00313831.2022.2042732

Jethro, O., Grace, A. M., and Thomas, A. K. (2012). E-learning and its effects on teaching and learning in a global age. *International Journal of Academic Research in Business and Social Sciences, 2*(1), 203-210.

Khany, R., & Boghayeri, M. (2014). How creative are Iranian EFL teachers? *Australian Journal of Teacher Education, 39*(10), 16-28. https://doi.org/10.14221/ajte.2014v39n10.2

Kim, W.C. and Mauborgne, R. A. (1998). Procedural justice, strategic decision making, and the knowledge economy. *Strategic Management Journal, 19*, 323-338.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science, 3*(3), 383-397.

Lander, G. (2014). 10 tips on how to use google plus hangouts. Jeffbullas. http://www.jeffbullas.com/2013/12/04/10-tips-on-how-to-use-google-plus-hangouts/.

Lee, Joosung. (2018). The effects of knowledge sharing on individual creativity in higher education institutions: Socio-technical view. *Administrative Sciences, 8* (2), 1-16. https://doi.org/10.3390/admsci8020021

Lewandowski, M. (2015), Creating virtual classrooms (using Google Hangouts) for improving language competency, Language Issues: *The ESOL Journal, 26*(1), pp. 37-42.

Li, Y., Kim, M. & Palkar, J. (2022). Using emerging technologies to promote creativity in education: A systematic review. *International Journal of Educational Research Open*, 3, 100177. https://doi.org/10.1016/j.ijedro.2022.100177

Lin,Y. S. (2011). Fostering creativity through education conceptual framework of creative pedagogy. *Creative Education, 2*(3), 149-155. https://doi.org/10.4236/ce.2011.23021

Martinez-Nunez, M., Borras-Gene, O. and Fidalgo-Blanco, A. (2016). Virtual learning communities I Google Plus, implications, and sustainability in MOOCs. *Journal of Information Technology Research (JITR), 9*(3), 18-36. https://doi.org/10.4018/JITR.2016070102

Mazhar, M., & Akhtar, M.S. (2018). Relationship between knowledge management and creativity among teachers of public and private sector universities at Lahore. *Bulletin of Education and Research, 40*(2), 91-104.

Nugroho, A., Haghegh, M., & Triana, Y. (2021). Emergency remote teaching amidst global pandemic: Voices of Indonesian EFL teachers. *VELES Voices of English Language Education Society, 5*(1), 66–80. https://doi.org/10.29408/veles%20journal.v5i1.3258

Parhamnia, F., & Farahian, M. (2021). EAP instructors' professional development and their knowledge sharing: a case of nursing courses. *Future of Medical Education Journal, 11*(1), 32- 38. https://doi.org/10.22038/fmej.2021.49314.1338

Pashazadeh, F., & Alavinia, P. (2019). Teacher creativity in light of autonomy and emotional intelligence. *Teaching English Language,13*(1), pp. 177-203. https://doi.org/10.22132/TEL.2019.89972

Ramli, R., Putra, F. A., & Fansury, A. H. (2022). Technology-based collaborative learning (TBCL) to enhance students' speaking performance during the COVID19 pandemic. *KLASIKAL: Journal of education, language teaching and science, 4*(2), 283–295. https://doi.org/10.52208/klasikal.v4i2.230

Richards, J. C. (2013). Creativity in language teaching. *Iranian Journal of Language Teaching Research, 1*(3), 19-43.

Runhaar P, Sanders K. (2015). Promoting teachers' knowledge sharing. The fostering roles of occupational self-efficacy and Human Resources Management. *Educational Management Administration & Leadership, 44*(5),1-20. https://doi.org/10.1177/1741143214564773

Schacter, J., Thum, Y. M., & Zifkin, D. (2006). How much does creative teaching enhance elementary school students' achievement? *The Journal of Creative Behavior, 40*(1), 47–72. https://doi.org/10.1002/j.2162-6057.2006.tb01266.x

Senge, P. (1997). Sharing knowledge. *Executive Excellence, 15*(6): 11-12.

Shih, R. C., & Lou, S. J. (2011). The development and application of a knowledge sharing behavior model for Taiwanese junior high school English teachers. *African Journal of Business Management, 5*(30), pp. 12066-12075. https://doi.org/10.5897/AJBM11.1281

Software Advice. (n.d.). *Adobe Connect vs Google Meet.* Software Advce. https://www.softwareadvice.com/voip/adobe-connect-profile/vs/google-meet/

Sternberg, R. J., & Grigorenko, E. L. (2004). Successful intelligence in the classroom. *Theory into Practice, 43*, 274–280.

Tsai, W., & Ghoshal, S. (1998). Social capital and value creation: the role of intrafirm networks. *Academy of Management Journal, 41*(4), 464-476.

Tseng, F-C.,& Kuo, F.Y. (2014). A study of social participation and knowledge sharing in the teachers' online professional community of practice. *Computers & Education,72*,37-47. https://doi.org/10.1016/j.compedu.2013.10.005

Van Den Beemt, A., Thurlings, M. and Willems, M. (2019), Towards an understanding of social media use in the classroom: A literature review. *Pedagogy and Education Technology, 29*(1), 35-55. https://doi.org/10.1080/1475939X.2019.1695657

Wang, Z. (2023). Linking innovative knowledge sharing and employees' innovative behaviour: the mediating role of thriving at work. *Knowledge Management Research & Practice*, 1–11. https://doi.org/10.1080/14778238.2023.2261411

Wenjuan, L. (2023). On the role of creativity in the application-oriented university students' engagement and success. *Heliyon, 9*(6), 1-6. https://doi.org/10.1016/j.heliyon.2023.e17374

Zamiri, M., & Esmaeili, A. (2024). Methods and technologies for supporting knowledge sharing within learning communities: A systematic literature review. *Administrative Sciences, 14*. https://doi.org/10.3390/admsci14010017

Zhang, X., Gao, Y., Yan, X., De Pablos, P. O., Sun, Y., & Cao, X. (2015). From e-learning to social-learning: Mapping development of studies on social media-supported knowledge management. *Computers in Human Behavior, 51*, 803-811. https://doi.org/10.1016/j.chb.2014.11.084

Ziegler, S.G. (2007). The (mis)education of Generation M. (2007). *Learning Media and Technology, 32*(1),69-81.

Appendix

The interview questions

1	Do online platforms have effect on teachers' creativity?
2	What are the advantages of using online platforms as learning tools?
3	What are the disadvantages of using online platforms as learning tools?
4	What are the characteristics of a good online platform as a learning tool?

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The effect of teaching history subjects in social studies course with digital games on student academic success and creative thinking

El efecto de enseñar materias de historia con juegos digitales en el éxito académico y el pensamiento creativo de los estudiantes de un curso de estudios sociales

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ABSTRACT

The purpose of this research is to investigate the impact of digital games on students' academic achievement and creative thinking in teaching historical subjects in social studies classes. The data for the research were collected using a mixed-methods model. The study group consists of 7th-grade students from two separate classes studying in a school affiliated with the Ministry of National Education within the boundaries of Erzurum province during the 2022-2023 academic year. Class A represents the experimental group, while Class B represents the control group. A total of 62 students participated in the research, with 31 in the experimental group and 31 in the control group. The quantitative data of the research were collected through Torrance Creative Thinking Test Verbal A-B Forms, an academic achievement test developed by the researcher, and a teacher observation form. The qualitative data were gathered using a semi-structured interview form developed by the researcher. The quantitative data analysis of the research was conducted using the SPSS 21.0 package program. A normality test was performed to determine whether the data followed a normal distribution. Parametric tests such as "Paired Samples t-test, Independent Samples t-test, and ANOVA" were used for the analysis of data showing normal distribution, whereas non-parametric tests like "Mann Whitney U Test and Wilcoxon Signed-Rank Test" were utilized for data that did not exhibit normal distribution. The qualitative data of the research were collected through the "Interview Form" and analyzed using content analysis with the MAQODA 20 analysis program. As a result of the research, it was concluded that digital games increased students' academic achievement and encouraged creative thinking. Additionally, according to student opinions, digital games influenced digital principles, creative thinking activities, and types of games. Students faced challenges in creating video games, particularly with video and writing applications during the process of digital game creation. In the research, considering that some students are more engaged in the fun and creative activities of lessons conducted through digital games, efforts should be directed towards enhancing student creativity and fostering a greater focus on learning. Given the recent development of digital games in various aspects of life, there is a need for further research in the field of digital game applications for educational purposes.

KEYWORDS Social studies; digital game-based learning; history teaching; academic achievement; creative thinking.

RESUMEN

El propósito de esta investigación es investigar el impacto de los juegos digitales en el rendimiento académico y el pensamiento creativo de los estudiantes en la enseñanza de materias históricas en las clases de estudios sociales. Los datos para la investigación se recopilaron mediante un modelo de métodos mixtos. El grupo de estudio está formado por estudiantes de séptimo grado de dos clases separadas que estudian en una escuela afiliada al Ministerio de Educación Nacional dentro de los límites de la provincia de Erzurum durante el año académico 2022-2023. La clase A representa el grupo experimental, mientras que la clase B representa el grupo de control. Un total de 62 estudiantes participaron en la investigación, 31 en el grupo experimental y 31 en el grupo de control. Los datos cuantitativos de la investigación se recopilaron a través de Torrance Creative Thinking Test Verbal A-B Forms, una prueba de rendimiento académico desarrollada por el investigador y un formulario de observación del maestro. Los datos cualitativos se recopilaron mediante un formulario de entrevista semiestructurada desarrollado por el investigador. El análisis de datos cuantitativos de la investigación se realizó utilizando el paquete de programas SPSS 21.0. Se realizó una prueba de normalidad para determinar si los datos seguían una distribución normal. Se utilizaron pruebas paramétricas como la "prueba t de muestras pareadas, la prueba t de muestras independientes y ANOVA" para el análisis de los datos que muestran una distribución normal, mientras que se utilizaron pruebas no paramétricas como la "prueba U de Mann Whitney y la prueba de rangos con signo de Wilcoxon". utilizado para datos que no exhibieron una distribución normal. Los datos cualitativos de la investigación fueron recolectados a través del "Formulario de Entrevista" y analizados mediante análisis de contenido con el programa de análisis MAQODA 20. Como resultado de la investigación, se concluyó que los juegos digitales aumentaron el rendimiento académico de los estudiantes y fomentaron el pensamiento creativo. Además, según las opiniones de los estudiantes, los juegos digitales influyeron en los principios digitales, las actividades de pensamiento creativo y los tipos de juegos. Los estudiantes enfrentaron desafíos en la creación de videojuegos, particularmente con aplicaciones de video y escritura durante el proceso de creación de juegos digitales. El estudio debe enfocarse en el desarrollo de la creatividad de los estudiantes y en la capacidad de centrarse más en el aprendizaje, teniendo en cuenta que algunos estudiantes participan más en actividades lúdicas y creativas en lecciones impartidas con juegos digitales. Dada la reciente expansión de las aplicaciones de juegos digitales en todos los aspectos de la vida, se necesita más investigación en los estudios de aplicaciones de juegos digitales orientadas a la educación.

PALABRAS CLAVE Estudios sociales; juego digital basado en el aprendizaje; enseñanza de historia; rendimiento académico; pensamiento creativo.

1. INTRODUCTION

The education system undergoes continuous changes with technological advancements, providing opportunities to offer more effective learning methods to students. In today's world, games have become a significant activity for children (Avidov-Ungar & Hayak, 2021; Mohanty et al., 2021). Games have recently captured the interest not only of children and teenagers but also of adults (Hébert et al., 2021). The importance of games today stems from their use as a source of entertainment for individuals. Engaging in games can be beneficial for individuals while also being a source of enjoyment. For instance, the use of digital games in education leads to the emergence of Digital Game-Based Learning (DGBL) (Chen et al., 2020; Perininet al., 2018).

In recent years, the integration of digital games into educational processes has the potential to provide students with effective and interactive learning experiences. Educational digital games have been shown to enhance students' learning levels and develop various creative abilities (Behnamnia et al., 2020). Digital games allow students to creatively tackle real-world problems (Cook & Bush, 2018). By positively influencing students' psychology, digital games enhance creative thinking skills. Therefore, digital games effectively contribute to

increasing students' real-life creative thinking skills and addressing challenges, exploring abilities, increasing motivation, and finding solutions to enhance learning (Avidov-Ungar & Hayak, 2021; Hsiao et al., 2014). Digital games play a role as tools to emphasize students' critical and creative thinking skills. Defined as technological tools where learning is concretely embodied, digital games enable students to solve their individual problems and make more creative decisions (Brunnet & Portugal, 2016; Gilavand, 2019; Hébert et al., 2021). There is a growing interest in using digital games in education. Digital games offer advantages such as making learning enjoyable, enhancing collaboration skills, and improving problem-solving abilities. These benefits can contribute to students learning historical topics more effectively in social studies classes. The potential of teaching historical events and concepts through digital games allows students to experience a more interactive and experiential learning process (Breien & Wasson, 2021; Chen et al., 2020; Pinto et al., 2023). While exploring historical contexts, students can enrich their learning experiences with activities such as making decisions, solving scenarios, and actively participating in historical events. This approach may help students develop in-depth understanding and critical thinking skills instead of simply memorizing information. Teaching history through digital games can increase students' capacities for creative thinking (Cook & Bush, 2018). Since games require problem-solving and strategy development, they can strengthen students' analytical thinking abilities. Additionally, by allowing students to evaluate and criticize historical events from different perspectives, games can support their creativity (Avidov-Ungar & Hayak, 2021; Ortega-Rodríguez et al., 2022). Especially in social studies classes, the aim is to provide students with a broad perspective on history, geography, culture, and societal issues to enhance awareness and develop critical thinking skills. In this context, the subject to be examined in this article is the impact of teaching history topics through digital games in social studies classes on students' academic success and creative thinking. Understanding how this innovative approach plays a role in strengthening students' abilities to comprehend, analyze, and criticize historical events indicates potential transformations in the field of education (Behnamnia et al., 2020).

1.1. Educational digital games

Teachers use various learning tools to motivate students for the lesson. Teachers who want to use an effective teaching tool in their lessons today apply digital games (Byun & Joung, 2018). Digital games are created on computers, smart phones and video games, keeping the student's knowledge in balance with real-life scenarios. An effective digital game must encourage students to experience the results of their actions by choosing the target they want to reach correctly. With digital games, students learn by trial and error by making mistakes in the learning process. It also allows them to design their own actions and review the process (Ashraf, 2020; Breien & Wasson, 2021; Chen et al.,2020; Kucher, 2021).

When applying digital games in education, it is necessary to design a game that includes teaching methods. Digital game applications should be at a level that will attract the attention of the student and motivate them for the lesson. Digital games in our age are divided into games and simulators (Chang et al., 2018). In games, there are goals and levels. It progresses gradually and successful completion of the task is ensured. A measurement is provided according to the skill acquired by the student (Kumar et al., 2021a). In simulation, learning takes place by interacting in an environment designed to animate the environment in which the individuals will apply their skills and knowledge in the computer environment. However, a simulation

is self-explanatory. One learns by interacting with a computerized environment designed to simulate the environment in which one will eventually apply their skills and knowledge (Alam, 2020; Wu et al., 2020).

Recently, there have been certain principles of digital games extensively utilized in education (Ashraf, 2020). Digital games empower students' creativity by offering opportunities to generate knowledge. The fundamental principles of digital games establish the basis of interaction in learning by connecting learning principles in digital environments (Wilson et al., 2020) and enhancing learning (Hsiao et al., 2014; Kaul et al., 2017).

Teachers who use digital games in their classes expect positive outcomes in students (Alam, 2020; Wu et al., 2020). Additionally, teachers desire a certain level of efficiency in the digital games they use in their classrooms (Kumar et al., 2021a). Students generally have high self-efficacy in operating digital games (Alam, 2020; Kumar et al., 2021a; Kumar et al., 2021b). Moreover, teachers need to have a certain level of competence to implement digital games in their classes (Gerber & Price, 2013).

1.2. Educational digital games and creative thinking

Creativity is generally defined as a human trait that brings forth positive emotions and personal satisfaction. The creative process is thought to be interdependent with creative domains, and the potential for creativity is considered to manifest in everyday creative actions (Csikszentmihalyi, 1996; Sternberg, 2012). The creative thinking process is identified in all individuals as the "capacity for original interpretation" and is characterized as an individual's ability for creative thinking without expertise or domain dependency. This process is emphasized as a central skill for all students in education (Kaufman & Beghetto, 2009). However, the insufficient inclusion of creativity in educational curricula is considered a significant limitation in modern school systems, despite the acknowledgment of the importance of creative and innovative thinking in all academic disciplines (Gangadharbatla, 2010; Root-Bernstein & Root-Bernstein, 1999).

Gangadharbatla (2010) expresses the need for new systems to understand the creative process, highlighting the necessity for technology integration. This suggests that technology tools can offer significant opportunities for fostering creative thinking in educational environments, providing various possibilities for students to enhance their creativity. Klausen (2010) points out the uncertainty about how students can be encouraged to think creatively in technology environments, emphasizing a lack of experimental groundwork in this regard. There is highlighted tension between technology-integrated learning and existing standards-based education. The conflict regarding whether the current educational standards are conducive to enhancing creative thinking skills is particularly emphasized. The avoidance of transformative and educational use of technology in traditional schools is noted, indicating a failure to fully leverage the potential of technology.

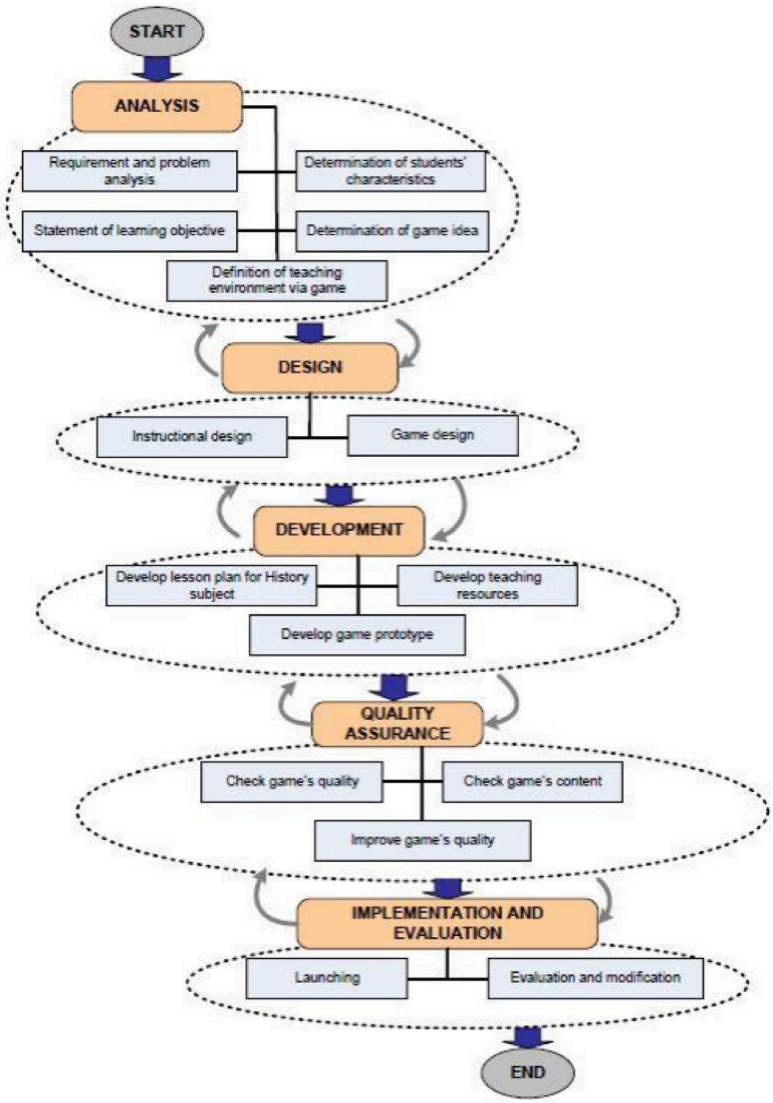
Researchers have suggested that the digital writing process can provide a robust learning environment and offer an opportunity for creative thinking directed towards internal learning. This indicates that students can not only create games but also enhance their digital writing skills (Robertson & Howells, 2008). Baytak and Land (2011) state that students can design games within a constructivist framework, and as design experience increases, so does their programming skills. Vos et al. (2011) suggest that game creation may be more motivating than game playing and can provide opportunities for using "deep learning strategies." Reynolds and Caperton (2011) determine that educational game design can provide an interesting and useful context for students to explore theoretical questions and discussions, engaging them in creative

thinking and presenting a positive learning experience. Game design and programming hold central importance in the development of technological literacy, supporting traditional text-based literacy (Caperton, 2010). Kafai (2006) expresses that the special role of games in contemporary children's culture, combined with a profound sense of attachment to activities related to games, creates a new and promising context for game studies. The reviewed literature demonstrates that understanding the creative thinking process in students during game design and development is crucial for addressing current educational challenges.

1.3. Using educational digital games in history education

The use of digital games holds significance in education, particularly in teaching history topics within social studies classes. The density of historical topics and the difficulty in using various teaching materials during class often lead to student boredom. Therefore, using digital games in teaching history topics in social studies classes can be beneficial. The model developed for history education through digital game-based learning holds significance in emphasizing the importance of digital games in teaching history topics (Zin et al., 2009). The foundational approach diagram and stages of digital game development for history-based learning are provided below.

FIGURE 1. Development of a History Teaching DGBL method (Zin et al., 2009)



Digital games, that have attracted great interest in education, have also started to be used in history teaching. Such games have started to be used, especially in social studies and history lessons. In this context, the use of digital games in history teaching has been the subject of research by drawing attention of many researchers. In the study of Wainwright (2014), who pioneered the studies in this field, applied the game called "Civilization" to history education. In this study, the effectiveness of the game in teaching critical thinking and history subjects was revealed. In their study Cruz et al. (2017) and Yu, et al., (2014) concluded that history teaching games have a positive effect on history teaching. In the study of Wainwright (2014) a similar conclusion was reached, as in other studies. In their study, Haataja et al.(2019) adapted "Assassin's Creed" to history subjects and as a result of the research, they concluded that students' interest in historical subjects increased, and they were more willing to produce new ideas on this subject. Alam (2020) and Kumari et al. (2021) investigated the effect on understanding historical subjects with the play "Europa Universalis II". Cózar-Gutiérrez and Sáez-López (2016) applied the game "Minecraft Edu" in history lessons and concluded that the game had a positive effect on student motivation and participation in the lesson. There are more studies reaching similar results (Bell & Gresalfi, 2017; Dukuzumuremyi & Siklander, 2018). Studies on history teaching mostly emphasize the development of students' understanding of historical subjects, critical thinking, decision making and problem-solving skills.

Digital games constitute the main purpose in terms of transferring the objectives in the curriculum to students. The main purpose here is digital-based games should not only serve as a means of entertainment, but also aim to reach the main goals of education by enabling students to develop creativity, attention and motivation. Considering the studies on the subject, there are not many studies aimed at improving student creativity and academic achievement of digital-based games used in history teaching. For this reason, there was a need for a study on the effect of digital games on students' academic achievement and creativity in teaching of history subjects in Social Studies course. Within the context of this purpose, a digital game for history teaching named "History with Me", which is about the "Culture and Heritage" unit of the Social Studies course, was designed. The game designed by students aims to reveal its effect on both the process and the course achievement and creativity. Within the context of this purpose, the problem sentence of the research is: How do digital games used in the teaching of history subjects in the Social Studies course effect the academic achievement and creative thinking of students? The sub-problems of the research are:

1. Is there a difference in achievement pre-post test scores between the control and experimental groups?
2. Is there a difference in creative thinking skills pre-post test scores between the control and experimental groups?
3. According to teacher observations, is there a difference in the performance of the control and experimental groups throughout the study period (pre-activity, during, and post-activity)?
4. What are the opinions of the experimental group students regarding the use of digital games in history teaching?

2. MATERIAL AND METHOD

2.1. Research model

The study investigating the impact of digital games on students' academic achievement and creativity in teaching history topics within the Social Studies course was conducted using a mixed research method, employing an explanatory sequential design. This design consists of two stages. In the first stage, quantitative data is collected, while in the second stage, qualitative data is gathered. In this design, multiple data collection tools (interviews, observations, visual and auditory materials, reports, documents) are used to collect data, which is then analyzed in-depth and categorized into themes (Creswell, 2016; Creswell & Clark, 2015). The quantitative data of the research was collected through a pre-test post-test control group experimental design, whereas the qualitative data followed a case study design.

FIGURE 2. Research model

2.2. Study group

The research study consists of 7th-grade students attending a school affiliated with the Ministry of National Education within the borders of Erzurum province in the 2022-2023 academic year, forming two separate classes. Class A represents the experimental group, while Class B represents the control group. A total of 62 students participated in the research, with 31 in the experimental group and 31 in the control group. Of these students, 30 are female, and 32 are male. It should be noted that the classes are not divided based on academic levels. In accordance with this, information was obtained from the school administration regarding how students were assigned to classes. It was indicated by the school administration that students were randomly assigned to classes, and the class levels were generally similar. In quantitative research methods, a probability-based sampling method, specifically random sampling, was employed. This type of sampling, based on probability theory, generally constitutes "good" samples (Christensen et al., 2014).

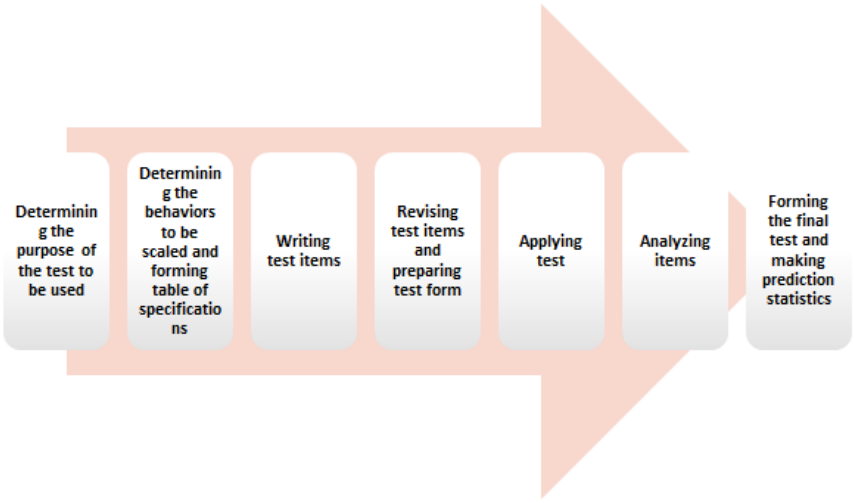
2.3. Data collection tools

Quantitative data of the study was collected with Torrance Creative Thinking Test Verbal A-B Forms, academic achievement test developed by the researcher, and teacher observation form. Qualitative data was collected with a semi-structured interview form developed by the researcher.

2.3.1. Achievement test

In the study, an achievement test was developed by the researcher to determine the academic achievement levels of the students. During the development process of the achievement test, an achievement test was developed by considering Crocker and Algina (1986). The development stages of the achievement test to be used in the research are indicated in the figure below.

FIGURE 3. The process of forming achievement test



The researcher prepared an achievement test to determine the level of knowledge of students participating in the study regarding the subject area before the experimental procedure and to measure their academic success after the experimental procedure. The process of preparing the achievement test took place in three stages.

In the first stage, a question pool was created taking into account the scope validity according to the achievements of the 7th-grade Culture and Heritage unit in the Social Studies Course. Source books and the 7th-grade Social Studies textbook were utilized in the preparation of the questions. While developing the achievement test, the achievements of the Culture and Heritage unit were taken into consideration.

In the second stage, considering the scope validity, the selection of questions for the pilot test was carried out, and the achievement test was prepared. The opinions of Social Studies teachers, educators in the field of Social Studies education, and faculty members working in the field of measurement and evaluation were obtained regarding question selection and scope validity in the prepared test. Necessary adjustments were made based on the opinions and suggestions of subject matter experts. A pilot test was then created in line with the opinions of experts. Subsequently, pilot implementation was carried out with the necessary permissions obtained from the Provincial Directorate and the Provincial Board of Education.

In the third stage, a reliability and item analysis study was conducted. Since the measurement tool used was multiple-choice, KR-20 reliability was examined. After the analyses, the questions were organized, and the achievement test was finalized by seeking expert opinions again. Considering the Academic Achievement test, the statistics related to the test are indicated in the table below.

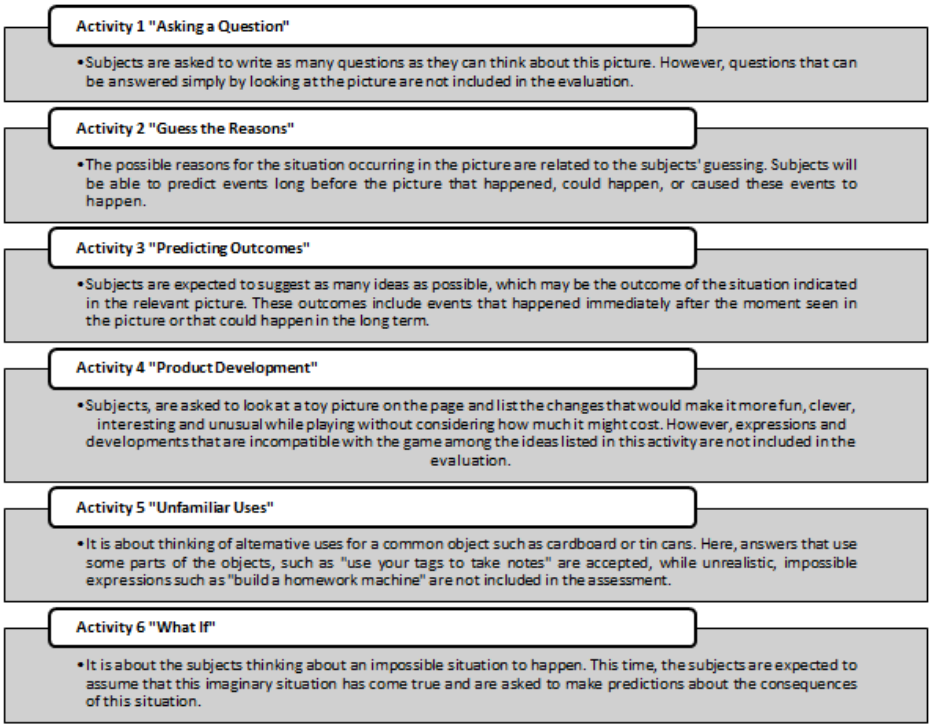
TABLE 1. Achievement test results statistic results

STATISTICS	VALUE
Number of questions	34
Average	14.789
Standard Deviation	7.096
Index of Distinctiveness	0.542
Difficulty Index	0.438
Coefficient of Reliability	0.876

2.3.2. Torrance creative thinking test (TCTT) verbal A-B forms

Considering former studies, it is seen that Torrance Creative Thinking Tests (TCTT) is the most cited test among the creative thinking tests. In addition, TCTT has a special importance as it directly measures creativity in terms of content (Kim, 2007). In this context, Torrance Creative Thinking Test Verbal A and B forms were used to measure the creativity of the students participating in the study considering digital games used in teaching of social studies course history subjects. The test was developed by Torrance in 1966. TCTT consists of four distinct factors: Fluency (idea), Flexibility (change), Originality (original idea) and elaboration (detail) (Kim, 2007; Torrance, 1972). Torrance Verbal Test of Creative Thinking consists of two distinct categories, A and B. This test can be applied to all age groups, from kindergarten to adults. There are six activities in each form of the test. In the test, 5 minutes are given for the 1st, 2nd, 3rd and 6th activities, and 10 minutes for the 4th and 5th activities. In total, the application time of the test is 40 minutes. TCTT is performed by calculating the sums of fluency, flexibility and originality measurement scores in 6 activities. In the TCTT Form, the first three of the activities begin with an indefinite picture. TCTT activities are indicated in the figure below.

FIGURE 4. Torrance creative thinking test (TCTT) verbal A-B forms activities



A validity and reliability study of TCTT was conducted. It was concluded that it had predictive validity in the tests performed. According to Cropley (2000), In the TCTT reliability study conducted by Torrance (1972), the reliability coefficient averages between the tests were not below 0.10. In the validity and reliability studies conducted for TCTT (Sungur, 1988), test-retest reliability correlation coefficients were found between 0.80 and 0.90. Aslan (2001), on the other hand, conducted TCTT reliability and validity studies and found that the correlation coefficients between the scores obtained in the test were significant at the $p<0.01$ level in all subtests. In the internal consistency calculation, correlation coefficients between ($r=0.38$) and ($r=0.89$) were obtained with Spearman Brown, Cronbach Alpha and Guttmann formulas. The lowest score of the group was calculated as the Cronbach Alpha value (0.50), and the highest internal consistency coefficient was found (0.71).

2.3.3. Interview form

In the study, it was aimed to investigate the effect of digital games on academic achievement and creative thinking in teaching social studies history subjects. In this process, digital games for history teaching were designed with students. It will also be important for future researches to examine deeply the thoughts of students involved in the studies regarding the process. In this context, the interview form was considered appropriate to receive the opinions of people and a semi-structured interview form was created by the researcher. The form was prepared by taking the opinions of academicians and teachers who are experts in their fields. Interview form was prepared in four categories. It was discussed in four sub-dimensions: (1) the effect of digital games on digital game principles, (2) the effect of digital games on game types, (3) the effect of digital games on creative thinking activities, and (4) the difficulties encountered in designing digital games. Interview questions were prepared as open-ended by examining the literature and put in a certain order (Karasar, 2002; Yıldırım & Şimşek, 2005). The interview form was given its final form by taking expert opinions.

The interview form consists of 4 questions. In order to inform the people who participated in the interview, an introduction section was added to the interview form and information about the interview process was given. In the interviews, both a voice recorder was used, and notes were taken. The MAXQODA 20 program was used in the analysis of the interviews. The data was analyzed by categorizing and presented in tables and graphs.

For the content validity of the prepared interview questions, opinions were received from academicians, who are experts regarding the subject. The pre-application interview questions were subjected to a pilot scheme. For the reliability of the interview, special care was taken to ask each question in the same way to all interviewees. For the analysis reliability of the interviews, the categories were coded to another person other than the researcher, and the percentage of agreement between them was checked. In addition, for coding reliability, the data was coded two separate times, and it was checked whether the same sentences were coded in the same category in both coding. Data that was not coded into the same category was excluded.

2.3.4. Teacher observation form

In the process of collecting the data of the research, a “structured observation form” was also used. An observation form was created by examining the literature about the behaviors of students during the activity

process (Goodson & Layzer, 2006). Observation form consists of three parts: before the activity, during the activity and after the activity. The observation form consists of items developed to code student behaviors. Each item was coded as 1 if it was observed once during the activity, and 0 if it was not observed at all. In addition, item frequencies were not coded. Before coding the data, two coders coded an experimental activity regarding how to code the observation forms. Cohen's kappa coefficient was calculated to ensure reliability among the coders, and it was found as $\kappa = .89$.

2.4. Process

The steps of the research process are listed as follows:

1. A proficiency test related to the "7th grade social studies curriculum culture and heritage learning area" has been prepared by the researcher.
2. Permission has been obtained from the provincial directorate of national education and relevant departments to pilot the proficiency test in order to test its validity and reliability.
3. The proficiency test has been pilot-tested to determine its validity and reliability.
4. Information has been acquired from relevant sources regarding the application and evaluation process of the "Torrance creative thinking verbal forms A and B" used as the data collection tool in the research.
5. A discussion form has been prepared by the researcher after obtaining opinions from expert academicians and teachers related to the subject.
6. The discussion form, refined based on expert opinions for content validity, has been administered to a total of 31 individuals after scheduling appointments.
7. Digital games designed to enhance students' academic achievement and creative thinking skills related to the "7th grade social studies curriculum culture and heritage learning area" have been created by reviewing the literature.
8. Approval has been obtained from the "ethics committee" and the "provincial directorate of national education" to conduct the application in a middle school within the boundaries of Erzurum during the first term of the 2022-2023 academic year.
9. A digital platform for the digital game application environment focused on teaching history topics in social studies has been prepared.
10. The classroom environment of the selected school for the application has been adjusted to be suitable for the experimental study.
11. Materials for the digital games planned for the "7th grade social studies curriculum culture and heritage learning area" have been transferred to the digital environment.
12. Two separate 7th-grade classes in the selected school have been randomly chosen. One class will follow the regular curriculum, while the other will be subjected to the application of digital games designed for teaching history in social studies.
13. A meeting has been held with the parents of the students involved in the experimental phase of the research with the approval of the school administration, providing them with information about their children's participation in the application study.

14. An introductory training of 8 hours has been conducted by the researcher for the group that will be involved in the digital games designed for teaching history in social studies.
15. Digital games for teaching history in social studies have been developed for a duration of 10 weeks.
16. Pre-test applications of "proficiency test and TCTT verbal form a" have been conducted for the selected experimental and control groups.
17. The experimental group was exposed to the digital games developed for teaching history in social studies, while the control group followed the regular curriculum methods and techniques for a period of 10 weeks.
18. At the end of the research, the "proficiency test and TCTT verbal form b" were administered as the final test to the experimental and control groups.

2.5. The process of creating a digital game

1. Initially, the basic idea and concept of the game were developed in collaboration with the students. At this stage, fundamental features such as the game's story, objectives, and main characters were determined.
2. Students, together with the researcher, designed the story of their game.
3. Students, in collaboration with the researcher, addressed elements such as game map designs and difficulty levels.
4. Designing the main characters and other characters was left to the responsibility of the students. Features such as the appearance and structures of animations were determined.
5. Rules and mechanics regarding how the game would be played were developed in collaboration with students. This included determining how players would interact and how the game would progress.
6. When designing the game's graphics, interface, and visual elements, students were assigned specific tasks. This stage involved creating animations and effects.
7. Students' opinions were taken into account when designing the game's sound effects and music. It was emphasized to students that sound design is crucial to enhance the atmosphere and emotional impact of the game.
8. To build the technical infrastructure of the game, students were shown relevant studies by the researcher.
9. At every stage of game design, the researcher and students tested the games to identify and correct errors, balance the gameplay, and optimize the overall gaming experience. Feedback was provided throughout the process.

2.6. Why the 'History with Me' game?

1. The game has the ability to operate on multiple platforms. The game provides the opportunity to work on different platforms, reaching a wider audience.
2. The game offers impressive visual effects, which are important for simulations or learning materials.
3. This game is a significant advantage for historical knowledge and problem-solving.

4. History topics are visually explained better through the game, making it more engaging for students.
5. The game's compatibility with different applications allows students to learn anytime, anywhere.

2.7. Analysis of data

The analysis of the data consists of two parts: quantitative and qualitative.

Quantitative data of the research was collected with "Academic Achievement Test and Torrance Creative Thinking Test Verbal A-B Forms and Teacher Observation Form". The "Academic Achievement Test" developed by the researcher consists of 30 questions, 24 of which are multiple choice and 6 of which are open-ended. Scores of the students from the multiple-choice questions in academic achievement test were scored according to the answer key created by the researcher. A maximum of 24 points is taken, with 1 point for each question. The lowest score was 0. The answers given by the students to the open-ended questions were evaluated in the context of creative thinking, fluency, flexibility and originality according to sub-dimensions. Student scores differ in the questions prepared in this category. The evaluation criteria of open-ended questions were evaluated in the context of the student's answer being appropriate for the question and having the quality of an answer. In this context, students received 1 fluency score for all answers. In addition, the answers given by all students for each open-ended question were divided into categories and 1 flexibility point was given for each category. Then, by reading the answers given by the students for each open-ended question, frequencies were created, and originality scores were determined according to the frequency of the answers given. For the score reliability of open-ended questions, another academician who worked on creativity apart from the researcher of the study made scoring. The correlational coefficient between scores the inter-rater reliability coefficient for the "TCTT Verbal A Form" was found 0.92, and the inter-rater reliability coefficient for the "TCTT Verbal B" was 0.93. Teacher observation form consists of three parts: before the activity, during the activity and after the activity. The teacher observation form consists of items developed to code student behaviors. Each item was coded as 1 if it was observed once during the activity, and 0 if it was not observed at all. In addition, item frequencies were not coded. There are 15 items in each part of the form, which consists of 45 items in total. The total score from each section is 15 and the total score is 45. In the analysis of the data, the analysis was made based on the total score obtained by the student from three sections. The analysis of the quantitative data of the research was conducted with the SPSS 21.0 package program. The normality test was performed to test whether the data of the study was normally distributed. "Related Samples t-test, Unrelated Samples t-test and ANOVA" were used in the analysis of normally distributed data, and non-parametric "Mann Whitney U Test and Wilcoxon Signed Rank Test" were used in the analysis of data that did not indicate normal distribution.

Qualitative data of the research was collected with the "Interview Form". The data obtained during the interview was analyzed by content analysis. MAQODA 20 analysis program was used in the analysis of the data. The data collected with the voice recorder was transferred to MAQODA 20 program and written. The data obtained from the interviews was organized by removing the unnecessary parts. During the coding phase of the data, codes were divided into categories (themes) determined according to the questions in the interview form. The codes created according to the questions in the interview form were brought together and examined by the researcher. The data presented was supported by direct examples from the interviewees.

3. RESULTS

TABLE 2. Mann Whitney U-test results of pre-test scores of control and experimental groups in cognitive domain steps of achievement test

COGNITIVE DOMAIN LEVEL	GROUP	n	MEAN RANK	TOTAL RANK	U	Z	p
Pretest Remembering	Control	31	32,65	1008,00	451,00	-0,45	,656
	Experiment	31	31,56	956,00			
Pretest Understanding	Control	31	32,37	1000,60	457,50	-0,35	,730
	Experiment	31	31,02	953,50			
Pretest Applying	Control	31	30,85	960,00	465,50	-0,24	,817
	Experiment	31	32,05	986,50			
Pretest Analyzing	Control	31	31,32	963,00	472,50	-0,14	,895
	Experiment	31	32,06	986,00			
Pretest Evaluating	Control	31	31,16	965,00	467,00	-0,22	,829
	Experiment	31	31,86	992,00			
Pretest Creating	Control	31	32,65	1010,00	449,00	-0,62	,543
	Experiment	31	30,92	946,00			

When Table 2 is observed it is seen that achievement pre-test scores of groups in each dimension of cognitive domain; *remembering* (U = 451.00; p > .05), *understanding* (U = 457.50; p > .05), *applying* (U = 465.50; p > .05)), *analyzing* (U = 472.50; p > .05, *evaluating* (U = 467.00; p > .05) and *creating* (U = 449.00; p > .05) did not indicate any statistically significant difference. When the mean ranks and totals of groups are examined, it is seen that control group's achievement scores are higher in "remembering, understanding and creating" dimensions of pre-experimental cognitive domain and experimental group's scores are higher in "applying, analyzing and evaluating" dimensions.

TABLE 3. T-Test results of the achievement test pre-test total scores of control and experimental groups

COGNITIVE DOMAIN LEVEL	GROUP	n	x̄	S	sd	t	p
Pretest Total Score	Control	31	8,42	4,12	60	0,47	,645
	Experiment	31	8,12	3,73			

When Table 3 is observed, it is seen that the mean achievement pretest total scores of the control and experimental groups did not indicate a significant difference (t60) = 0.47; p > .05). However, it is seen that mean total achievement score of control group before the experiment (x̄=8.42) is higher than total mean score of experimental group (x̄=8.12).

TABLE 4. Mann Whitney U-test results of control and experimental groups' post-test scores in cognitive domain levels of achievement test

COGNITIVE DOMAIN LEVEL	GROUP	n	MEAN RANK	TOTAL RANK	U	Z	p
Posttest Remembering	Control	31	29,50	884,00	388,00	-1,34	,183
	Experiment	31	35,50	1069,00			
Posttest Understanding	Control	31	28,13	1000,60	373,50	-1,57	,119
	Experiment	31	34,99	953,50			
Posttest Applying	Control	31	27,47	869,00	356,50	-1,81	,072
	Experiment	31	35,65	1085,50			
Posttest Analyzing	Control	31	29,78	852,50	444,00	-0,55	,589
	Experiment	31	33,72	1110,00			
Posttest Evaluating	Control	31	29,14	940,00	403,00	-1,17	,244
	Experiment	31	35,02	1015,00			
Posttest Creating	Control	31	30,52	955,00	459,00	-0,32	,751
	Experiment	31	33,42	1000,00			
Posttest Total Score	**Control**	**31**	**28,98**	**873,00**	**377,00**	**-1,48**	**,141**
	Experiment	**31**	**34,96**	**1082,00**			

When Table 4 is examined no statistically significant difference was observed between achievement pre-test scores of groups in each dimension of cognitive domain remembering (U = 388.00; p > .05), understanding (U = 373.50; p > .05), applying (U = 356.50; p > .05)), analyzing (U = 444.00; p > .05, evaluating (U = 403.00; p > .05) and creating (U = 459.00; p > .05) and posttest total scores (U = 376.00; p > .05).

TABLE 5. T-test results of TCTT verbal A and B forms creativity total scores of control group students

GROUP	TEST TYPE AND DIMENSION	n	x̄	S	sd	t	p
Control	Verbal Fluency A Form	31	26,68	7,74	30	-1,99	,059
	Verbal Fluency B Form	31	29,89	11,37			
	Verbal Flexibility A From	31	17,31	5,73	30	-1,88	,078
	Verbal Flexibility B Form	31	19,06	6,37			
	Verbal Originality A From	31	15,78	5,45	30	-1,51	,156
	Verbal Originality B From	31	17,84	9,25			
	Verbal A Form. Total Score	**31**	**59,01**	**18,25**	**30**	**-1,97**	**,071**
	Verbal B Form. Total Score	**31**	**66,02**	**26,03**			

When Table 5 is examined, no statistically significant difference was observed among pretest-posttest fluency ((30) = −1,99; p > .05), flexibility (t(30) = −1,88; p > .05) and originality scores and mean scores (t(30) = −1,51; p > .05) and total scores (t(30) = −1,97; p > .05) of control group. When the mean scores of the TCTT Verbal A and B forms dimensions of the control group are examined, it is seen that posttest mean scores are higher than pretest mean scores considering all mean scores. Likewise, the control group's post-test mean scores (x̄=66,02) were higher than the pre-test mean scores (x̄=59,01).

TABLE 6. T-test results of TCTT Verbal A and B forms creativity total scores of the experimental group students

GROUP	TEST TYPE AND DIMENSION	n	x̄	S	sd	t	p
Experiment	Verbal A FormFluency	31	27,02	12,65	30	-7,86	,000*
	Verbal B FormFluency	31	41,38	16,94			
	Verbal A FormFlexibility	31	17,03	6,78	30	-7,92	,000*
	Verbal B FormFlexibility	31	24,98	7,02			
	Verbal A FormOriginality	31	15,12	7,74	30	-8,35	,000*
	Verbal B FormOriginality	31	31,02	13,99			
	Verbal A FormTotal Puan	**31**	**58,35**	**25,85**	**30**	**-8,83**	**,000***
	Verbal B FormTotal Puan	**31**	**97,06**	**36,96**			

When Table 6 is examined, statistically significant difference was observed between the pretest-posttest fluency ((30) = −7,86; p< .05), flexibility (t(30) = −7,92; p< .05) and originality scores of experimental group and the mean scores (t(30) = −8,35; p < .05) of their total scores (t(30) = −8,83; p < .05).

TABLE 7. T-test results of the mean scores of the control and experimental groups in each dimension of the TCTT verbal A form and the total creativity scores

TEST TYPE AND DIMENSION	GROUPS	n	x̄	S	sd	t	p
Verbal A Form	Control	31	26,68	7,74	60	-0,07	,990
Fluency	Experiment	31	27,02	12,65			
Verbal A Form	Control	31	17,31	5,73	60	0,25	,843
Flexibility	Experiment	31	17,03	6,78			
Verbal A Form	Control	31	15,78	5,45	60	0,56	,634
Originality	Experiment	31	15,12	7,74			
Verbal A Form	**Control**	**31**	**59,01**	**18,25**	**60**	**0,21**	**,872**
Total Puan	**Experiment**	**31**	**58,35**	**25,85**			

When Table 7 is examined, it is seen that the control and experimental groups' TCTT pre-test fluency ((60) = −0,07; p > .05), flexibility (t(60) = 0,25; p > .05) and originality (t(60) = 0,56; p > .05) and total scores (t(60) = 0,21; p > .05) mean that there is no statistically significant difference. When the averages of the creativity pre-test scores of the groups are examined, it is understood that the averages of both groups in all dimensions and total scores are close to each other.

TABLE 8. T-test results of the mean scores of the control and experimental groups in each dimension of the TCTT verbal B form and the total creativity scores

TEST TYPE AND DIMENSION	GROUPS	n	x̄	S	sd	t	p
Verbal B Form	Control	31	29,9	11,37	60	-3,19	,003*
Fluency	Experiment	31	41,38	16,94			
Verbal B Form	Control	31	19,06	6,37	60	-3,80	,000*
Flexibility	Experiment	31	24,98	7,02			
Verbal B Form	Control	31	17,84	9,25	60	-4,36	,000*
Originality	Experiment	31	31,02	13,99			
Verbal B FormΩ	**Control**	**31**	**66,02**	**26,03**	**60**	**-3.81**	**,000***
Total Puan	**Experiment**	**31**	**97,06**	**36,96**			

When Table 8 is examined, considering the control and experimental groups' TCTT posttest fluency ((60) = −3,19; $p < .05$), flexibility ($t(60) = -3{,}80$; $p < .05$) and originality ($t(60) = -4{,}36$; $p < .05$) and total mean scores ($t(60) = -3{,}81$; $p < .05$) it is seen that there is a statistically significant difference. When the posttest mean scores of the control and experimental groups are examined, the mean scores in all dimensions of the creativity test differ on behalf of experimental group.

TABLE 9. ANOVA results of the mean scores of the experimental group from the teacher observation form in the digital game creation process

VARIABLE	n	x̄	ss	sd	F	p	TUKEY
Activity							
(1) Before the Activity	31	9,03	4,52	30	5,46	,001*	1-2
(2) During the Activity	31	11,12	3,56				1-3
(3) After the Activity	31	13,43	2,98				2-3

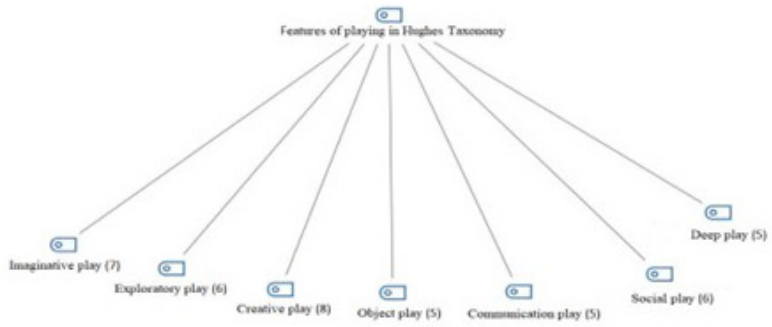
When Table 9 is examined, it is seen that there is a significant difference in experimental group's before, during and after the experiment total scores of the teacher observation form ($F(30) = 5.46$, $p < .05$). Post-hoc tests were conducted to observe this difference. As a result of Tukey test, there is a difference in the total scores at each stage of the activities according to the teacher's observation.

FIGURE 5. Contribution of digital games developed to apply in history teaching to the development of digital game principles

According to students' opinions, the effect of digital games developed in the teaching of history subjects in social studies course on the development of digital game principles was indicated through seven codes. According to this, the students stated the effect of digital games developed in the teaching of history subjects in social studies course on the development of digital game principles each of the codes of inspiration, attention, and satisfaction 6 times, they stated each of the codes of personification, gamification, relevance and confidence 5 times (see Figure 5).

S12 "The activities we did together with my teacher during the process attracted my attention a lot. I love playing games on the computer anyway. As a result, my attention to the lesson and the activities increased."

FIGURE 6. The effect of digital games developed to apply in history teaching on the development of game types

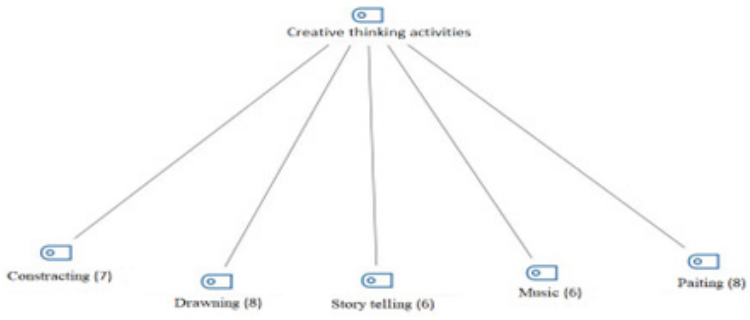


According to student opinions, the effect of digital games developed in teaching of history subjects in social studies course on the development of Hughes Taxonomy (2002) game types was indicated via seven codes.

According to this, students stated the effect of digital games developed in teaching of history subjects in social studies course on the development of digital game genres 6 times for exploratory and social play codes, creative play 8, imaginative play 7 and they stated each of the object, deep and communication play codes 5 times (see Figure 6).

S9 "In social studies course, our teacher made us play games about history. But I love games with objects like building blocks. If it is done in other lessons, I will tell our teacher to make such games."

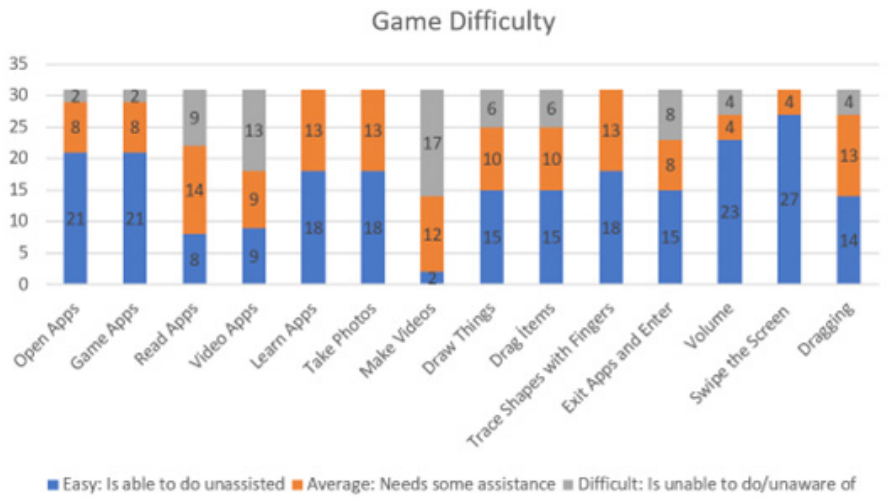
FIGURE 7. The effect of digital games developed to apply in history teaching on the development of creative thinking activity



According to students' opinions, the effect of digital games developed in teaching of history subjects in social studies course on the development of creative thinking activities was indicated via five codes. According to this, students stated each of the drawing and painting codes 8 times, constructing 7 times, they stated each of the storytelling and music codes 8 times (see Figure 7).

> S31 "I always tell my father that I will study computer and software engineering when I grow up. I say that after I become an engineer, I will make and sell games. I thought that I got this opportunity my social studies class. I told my teacher that I could do it myself not to interfere with me. My teacher was surprised but appreciated me. Every aspect of digital game creation has impressed me. When I grow up, if I become a computer and software engineer, I will not forget that these activities made a first impression on me."

FIGURE 8. Difficulties encountered in digital game steps developed to apply in history teaching



It is seen that students have difficulties in the process of creating videos, mostly with video and writing applications, in the process of creating digital games developed for learning history topics in social studies course. They had no difficulty in drawing shapes, sound, screen scrolling, opening the application. It is seen that they did it by dragging and helping the application in reading (see Figure 8).

4. DISCUSSION

The first two questions of the research focused on the effect of digital games on the academic achievement of students in teaching of history subjects in social studies course. According to the results obtained in this context, the academic achievements of the groups before the experiment indicate similarities with each other. In the achievement test after the experiment, it was concluded that the scores between groups differed on behalf of experimental group. According to form Chen studies (Chen & Law, 2016; Kangas et al., 2017; Makar et al., 2015; Van de Pol et al., 2010), it was found that digital games have a significant effect on student academic achievement and lessons form an important framework. In small group studies, it was determined that digital games increase students' academic achievement (Makar et al., 2015). In addition

students' taking the leading role by creating digital games had a considerable effect on increasing the achievement of the course. Students can solve a given problem individually with digital games, recognize the difficulties and offer suggestions. This situation increases the student's achievement and interest in the lesson (Muhonen et al., 2016; Nousiainen et al., 2018). As a result, digital games create a process of creating a structure that supports students by interacting with students in the process and under the guidance of the teacher. When the structure of the course process takes on this dimension, it will be inevitable to increase the course achievement of the student (Nousiainen et al., 2018; Watson et al. 2011). Banihashem and others (2023) emphasize the importance of game-based learning (GBL) for educators to monitor the effectiveness of learning, identify gaps in learning during the game, and provide appropriate interventions to enhance learning quality. Additionally, GBL enables a better representation of the relationship between learning goals. Noroozi (2018) conducted a study that focused on how higher education students with various epistemic beliefs engage in discussions within a digital dialogue game and how their attitudes are influenced. The study observed that the digital dialogue game could guide students towards the desired mode of interaction and discussion, and it was noted to be a significant factor in the attitudinal changes related to their epistemic beliefs. Additionally, students' epistemic beliefs influenced the style and frequency of a specific type of argumentative dialogue. Students with multiple perspectives participated in argumentative dialogue activities differently compared to evaluators. Dehghanzadeh et al. (2021) argues that digital gamification is a fun and enjoyable method to support learning English as a Second Language (LESL) and alleviate the gap between students' learning and educational applications. Furthermore, through gamification, students engage with LESL while mapping their learning experiences and outcomes. While positive effects of gamification on learners' learning experiences and outcomes have been reported in these studies, none of the publications specify gamification elements associated with learning experiences and outcomes. Being enjoyable, engaging, motivating, and fun are the targeted learning outcomes of gamified LESL in terms of language acquisition, participation, motivation, and satisfaction. Noroozi (2017) investigated how undergraduate students engaged in discursive discourse activities designed to intensify discussion in a digital dialogue game. The research findings suggest that the digital dialogue game can facilitate discussion-based learning. From the students' perspectives, the digital dialogue game was positively evaluated in terms of satisfaction and learning experiences.

The third and fourth questions of the research focused on the effect of digital games on students' creative thinking skills in teaching of history subjects in social studies course. According to the results obtained in this context, it is similar to creative thinking skill test before the intergroup experiment. In the creative thinking test performed after the experiment, it was concluded that there was a difference in the scores between the groups on behalf of the experimental group. The fifth question of the research focused on the change of the student according to the teacher observation form before, during and after the activity of the digital games designed in teaching of history subjects in social studies course. According to the results obtained in this context students' observation scores before, during and after the activity differ in the digital game design process. It was seen that students' creative thinking skills and learning situations are different in the courses in which the digital games chosen by the teachers are applied. In terms of interpreting digital games in the context of pedagogical principles, it encourages students to develop skills such as creativity, collaboration and critical thinking (Tropper et al., 2015). Digital games take the student out of traditional classroom environment and bring them to the real world. This provides the opportunity to increase student

creativity and sense of research more. However, teachers need to know more and do more research on how to design digital games with creative components to enhance students' creativity (Sun et al., 2021).

The results for the six, seven and eight questions of the study were found by taking the opinions of experimental group students. Questions directed to students focused on the effects of the design process of digital games on digital game principles, digital game genres and creative thinking activities. The ninth question of the research focused on the difficulties faced by students in designing digital games to be used in history teaching. Students will be able to learn the effects of digital games developed in teaching of history subjects in social studies course on the development of digital game principles, inspiration, attention, satisfaction, personification, gamification, relevance and confidence. Students learn the effects of digital games developed in teaching of history subjects in social studies course on the development of game genres; creative, imaginative, exploratory, social, object, deep and communicative play. Students learn the effect of digital games developed in teaching of history subjects in social studies course on the development of creative thinking activities, drawing, painting, creating, storytelling and music. At the stage of creating the digital games developed for learning history subjects in the social studies lesson, the students stated that they had difficulties in the process of creating videos with video and writing applications, they did not have difficulty in drawing shapes, sound, screen scrolling, opening the application, and they did it by dragging and helping in reading the application. The pedagogical principles of digital game-based learning applications encourage students for the basic elements of digital game such as fantasy, curiosity and challenge in the context of creativity, problem solving, and critical thinking (Tropper et al., 2015). In the context of creativity, if the components of digital games are combined with social studies subjects, the course becomes more interesting. Digital games designed based on the components of digital games in education strengthen students' creative thinking, problem solving and interaction skills. However, more studies are needed to understand this situation better (Behnamnia et al., 2020; Grammenos & Antona, 2018; Meletiou-Mavrotheris & Prodromou, 2016). While designing digital games, teachers must try to understand how the student's creativity develops while using the game. For students to actively take part in the digital game process, they need to have technology and related skills. Digital games that encourage creativity must be designed within the framework of principles that will improve student creativity. Digital games designed for this purpose make learning easier and more effective by putting the classroom atmosphere into a different dimension (Barzilai & Blau, 2014; Gong, 2020). Digital games with creative components will help students to have fun, learn and interact. In addition to improving learning, it will improve the student's ability to cooperate (Muhonen et al., 2016; Sun et al., 2021).

The findings of the current research indicate that digital games must add some practical features to the games according to the purpose of education in order to encourage academic achievement and creativity. It must be noticed that higher quality digital games will be a key factor in improving students' achievement and creativity. It is important that digital games make some changes at the secondary school level when applying them to the subjects in the curriculum. Considering that students take part more in the entertainment and creative activities of the lessons taught with digital games, teachers must consider the level of difficulty in teaching the subject. In this case, the student can focus more on developing creativity and learning. More research is needed for educational digital game applications since digital games have been developed in all areas of life recently (Bakker et al., 2016; Drijvers et al., 2014; Rienties et al., 2012).

4.1. Limitations and Future research

This study revealed meaningful outcomes in terms of student academic achievement and creativity in the context of teaching history topics using digital-based games in social studies classes; however, assessing general dependency information in a single study is impossible. There are some limitations in this study that pave the way for future research. The limitations of our study are as follows: Firstly, all participants were from the same city and limited to one middle school, so they may have similar behavior attitudes. Secondly, other personal factors or environmental conditions, such as academic performance and creative thinking, may affect levels of dependency. For future studies, obtaining better information about the academic achievement and creativity levels of students with digital games with wider sampling groups and independent variables will be helpful.

5. CONCLUSIONS

The purpose of this research is to investigate the effect of digital games on student academic achievement and creative thinking in the teaching of history subjects in social studies course. The data of the research was collected using the mixed method model. The research suggests that digital game development process in the social studies course, increase students' academic achievement and encourage them to develop creative thinking. In addition, the relationship between digital game components and creativity was investigated. Digital games are discussed in the context of digital game principles in developing creativity. In the research, the role of teachers in this process was also mentioned for digital games to strengthen students' academic achievement and creativity. Because teachers, who are at the center of education, have a key role in increasing students' learning, creative thinking and motivation. In addition, the teacher empowers students to face problems in the real world and helps them understand the problems and challenges of digital games. This research might have a significant impact on students being more creative in solving future life problems. In addition, it offers an important perspective to digital game designers and researchers working in this field. The research offers important suggestions on how to improve achievement and creative thinking, and how to motivate learning outcomes by taking support from digital games in the teaching of history subjects in social studies course.

6. REFERENCES

Alam, A. (2020). Conceptualization of Cultural ıntelligence, ın-tercultural sensitivity, ıntercultural competence, and nomo-logical Network: A contact hypothesis study of sociology of education. *Movimento-Revista de Educação, 7*(15), 217-258. https://doi.org/10.22409/mov.v7i15.45814

Ashraf, A. (2020). Challenges and possibilities in teaching and learning of calculus: A case study of India. *Journal for the Education of Gifted Young Scientists, 8*(1), 407-433. https://doi.org/10.17478/jegys.660201

Aslan, A. E., (2001). Torrance Yaratıcı Düşünce Testi'nin Türkçe versiyonu, *M.Ü. Atatürk Eğitim Fakültesi Eğitim Bilimleri Dergisi,* 14, 19-40.

Avidov-Ungar, O., & Hayak, M. (2021). Teacher perception of the adoption and ımplementation of dgbl in their classroom

teaching: adoption and ımplementation of DGBL among teachers. *International Journal of Game-Based Learning (IJGBL), 11*(1), 17-30. https://doi.org/10.4018/IJGBL.2021010102

Bakker, M., Van den Heuvel-Panhuizen, M., & Robitzsch, A. (2016). Effects of mathematics computer games on special education students' multiplicative reasoning ability. *British Journal of Educational Technology, 47*(4), 633-648. https://doi.org/10.1111/bjet.12249

Banihashem, S. K., Dehghanzadeh, H., Clark, D., Noroozi, O., & Biemans, H. J. (2023). Learning analytics for online game-Based learning: a systematic literature review. *Behaviour & Information Technology*, 43(12), 2689–2716. https://doi.org/10.1080/0144929X.2023.2255301

Barzilai, S., & Blau, I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences. *Computer & Education, 70*, 65-79. https://doi.org/10.1016/j.compedu.2013.08.003

Baytak, A., & Land, S. (2011). An investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom. *Educational Technology Research & Development, 59*(6), 765-782. http://dx.doi.org/10.1007/s11423-010-9184-z.

Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, A. (2020). The effective components of creativity in digital game-based learning among young children: A case study. *Children and Youth Services Review,* 116, 105227. https://doi.org/10.1016/j.childyouth.2020.105227

Bell, A., & Gresalfi, M. (2017). Teaching with videogames: How experience impacts classroom integration. *Technology, Knowledge and Learning, 22*, 513–526. https://doi.org/10.1007/s10758-017-9306-3

Breien, F. S., & Wasson, B. (2021). Narrative categorization in digital game-based learning: Engagement, motivation & learning. *British Journal of Educational Technology, 52*(1), 91-111. https://doi.org/10.1111/bjet.13004

Byun, J., & Joung, E. (2018). Digital game-based learning for K–12 mathematics education: A meta-analysis. *School Science and Mathematics, 118*(3-4), 113-126. https://doi.org/10.1111/ssm.12271

Brunnet, N., & Portugal, C. (2016). Digital Games and Interactive Activities: Design of Experiences to Enhance Children Teaching-Learning Process. *International Journal of Modern Education & Computer Science, 8*(12), 1-9. https://doi.org/10.5815/ijmecs.2016.12.01

Caperton, I. H. (2010). Toward a theory of game-media literacy. *International Journal of Gaming and Computer-Mediated Simulations, 2*(1), 1–16. http://dx.doi.org/10.4018/jgcms.2010010101.

Chang, C.-C., Warden, C. A., Liang, C., & Lin, G.-Y. (2018). Effects of digital game-based learning on achievement, flow and overall cognitive load. *Australasian Journal of Educational Technology, 34*(4). https://doi.org/10.14742/ajet.2961

Chen, C.-H., & Law, V. (2016). Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation. *Computers in Human Behavior, 55*, 1201–1212. https://doi.org/10.1016/j.chb.2015.03.010

Chen, C.-H., Shih, C.-C., & Law, V. (2020). The effects of competition in digital game-based learning (DGBL): a meta-analysis. *Educational Technology Research and Development, 68*(4), 1855-1873. https://doi.org/10.1007/s11423-020-09794-1

Cook, K. L., & Bush, S. B. (2018). Design thinking in integrated STEAM learning: Surveying the landscape and exploring exemplars in elementary grades. *School Science and Mathematics, 118*(3-4), 93-103. https://doi.org/10.1111/ssm.12268

Cózar-Gutiérrez, R., & Sáez-López, J. M. (2016). Game-based learning and gamification in initial teacher training in the social sciences: an experiment with Minecraf-tEdu. *International Journal of Educational Technology in Higher Education*, *13*(1), 1-11. https://doi.org/10.1186/s41239-016-0003-4

Creswell, J. W. (2016). *A concise introduction to mixed methods research.* SAGE publications.

Creswell, JW & Clark, VLP (2015). *Pesquisa de Métodos Mistos-: Série Métodos de Pesquisa.* Penso Editora.

Crocker, L., & Algina, J. (1986). *Introduction to classical and modern test theory.* Holt, Rinehart and Winston.

Cropley, A. J. (2000). Defining and measuring creativity: Are creativity tests worth using?. *Roeper review, 23*(2), 72-79.

Cruz, S., Carvalho, A.A.A. & Araújo I. (2017). A game for learning history on mobile devices. *Educ Inf Technol*, 22, 515-531. https://doi.org/10.1007/s10639-016-9491-z

Csikszentmihalyi, M. (1997). Flow and the psychology of discovery and invention. *HarperPerennial, New York, 39*, 1-16.

Dehghanzadeh, H., Fardanesh, H., Hatami, J., Talaee, E., & Noroozi, O. (2021). Using gamification to support learning English as a second language: a systematic review. *Computer Assisted Language Learning, 34*(7), 934-957. https://doi.org/10.1080/09588221.2019.1648298

Drijvers, P., Doorman, M., Kirschner, P., Hoogveld, B., & Boon, P. (2014). The effect of online tasks for algebra on student achievement in grade 8. *Technology, Knowledge and Learning, 19*, 1–18. https://doi.org/10.1007/s10758-014-9217-5

Dukuzumuremyi, S., & Siklander, P. (2018). Interactions between pupils and their teacher in collaborative and technology-enhanced learning setting in the inclusive classroom. *Teaching and Teacher Education, 76*, 165–174. https://doi.org/10.1016/j.tate.2018.08.010

Gangadharbatla, H. (2010). Technology component: a modified systems approach to creative thought. *Creativity Research Journal, 22*(2), 219–227. http://dx.doi.org/10.1080/10400419.2010.481539

Gerber, H. R., & Price, D. P. (2013). Fighting baddies and collecting bananas: Teachers' perceptions of games-based literacy learning. *Educational Media International, 50*(1), 51-62. https://doi.org/10.1080/09523987.2013.777182

Gilavand, A. (2019). The impact of using the Iranian Red Crescent Society Educational Mobile App on improving the students' awareness of first aids. *Journal of Comprehensive Pediatrics, 10*(1), 1-6. https://doi.org/10.5812/compreped.67828

Goodson, B. D. & Layzer, J. I. (2006). The "quality" of early care and education settings: Definitional and measurement issues. *Evaluation review*, *30*(5), 556-576. https://doi.org/10.1177/0193841X06291524

Gong, S. (2020). On the cultivation of middle school students' creativity. *English Language Teaching, 13*(1), 134-140. https://doi.org/10.5539/elt.v13n1p134

Grammenos, D., & Antona, M. (2018). Future designers: Introducing creativity, design thinking & design to children. *International journal of child-computer interaction, 16,* 16–24. https://doi.org/10.1016/j.ijcci.2017.10.002

Haataja, E., Moreno-Esteva, E. G., Salonen, V., Laine, A., Toivanen, M., & Hannula, M. S. (2019). Teacher's visual attention when scaffolding collaborative mathematical problem solving. *Teaching and Teacher Education, 86*, 1-15. https://doi.org/10.1016/j.tate.2019.102877

Hsiao, H. S., Chang, C. S., Lin, C. Y., & Hu, P. M. (2014). Development of children's creativity and manual skills within digital game-based learning environment. *Journal of Computer Assisted Learning, 30*(4), 377–395. https://doi.org/10.1111/jcal.12057

Hébert, C., Jenson, J., & Terzopoulos, T. (2021). "Access to technology is the major challenge": Teacher perspectives on barriers to DGBL in K-12 classrooms. *E-Learning and Digital Media, 18*(3), 307-324. https://doi.org/10.1177/2042753021995315

Hughes, B. (2002). *A playworker's taxonomy of play types.* PlayLink.

Kafai, Y. B. (2006). Playing and making games for learning instructionist and constructionist perspectives for game studies. *Games and Culture, 1*(1), 36–40. http://dx.doi.org/10.1177/1555412005281767

Kangas, M., Koskinen, A., & Krokfors, L. (2017). A qualitative literature review of educational games in the classroom: The teacher's pedagogical activities. *Teachers and Teaching, 23*(4), 451–470. https://doi.org/10.1080/13540602.2016.1206523

Karasar, N. (2002). *Bilimsel araştırma yöntemi: Kavramlar, ilkeler, teknikler.* Nobel Yayın Dağıtım.

Kaufman, J. C., & Beghetto. (2009). Beyond big and little: the four c model of creativity. *Review of General Psychology, 13*(1), 1-12. https://doi.org/10.1037/a0013688

Kaul, V., Bhattacharjea, S., Chaudhary, A. B., Ramanujan, P., Banerji, M., & Nanda, M. (2017). *The India early childhood education impact study*. UNICEF.

Kim, K.-H., 2007, The Two Torrance Creativity Tests: The Torrance Tests of Creative thinking and thinking creatively in action and movement. In A. Tan (Eds.), *Creativity a handbook for*

teachers (pp. 117-141). World Scientific Publishing Co. Pte. Ltd. https://doi.org/10.1142/9789812770868_0007

Klausen, S. H. (2010). The notion of creativity revisited: a philosophical perspective on creativity research. *Creativity Research Journal, 22*(4), 347–360. http://dx.doi.org/10.1080/10400419.2010.523390.

Kucher, T. (2021). Principles and Best Practices of Designing Digital Game-Based Learning Environments. *International Journal of Technology in Education and Science, 5*(2), 213-223. https://doi.org/10.46328/ijtes.190

Kumar, D., Alam, M., & Polat, K. (2021a). Interactive Attendance System for Modern Education Using Computational Intelligence. *Journal of the Institute of Electronics and Computer, 3*(1), 75-86. https://doi.org/10.33969/JIEC.2021.31006

Kumar, P., Alam, A., & Wang, J. (2021b). Estimation of low velocity impact on the scarf repair GFRP composite: Experimental method. *Materials Today: Proceedings, 43,* 731-739. https://doi.org/10.1016/j.matpr.2020.12.853

Makar, K., Bakker, A., & Ben-Zvi, D. (2015). Scaffolding norms of argumentation-based inquiry in a primary mathematics classroom. *ZDM Mathematics Education, 47*, 1107–1120. https://doi.org/10.1007/s11858-015-0732-1

Meletiou-Mavrotheris, M., & Prodromou, T. (2016). Pre-service teacher training on game-enhanced mathematics teaching and learning. *Technology, Knowledge and Learning, 21*(3), 379-399. https://doi.org/10.1007/s10758-016-9275-y

Mohanty, A., Alam, A., Sarkar, R., & Chaudhury, S. (2021). Design and Development of Digital Game-Based Learning Software for Incorporation into School Syllabus and *Curriculum Transaction. Design Engineering,* 8, 4864-4900.

Muhonen, H., Rasku-Puttonen, H., Pakarinen E., & Poikkeus, A.-M. (2016). Scaffolding through dialogic teaching in early school classrooms. *Teaching and Teacher Education, 55*, 143-154. https://doi.org/10.1016/j.tate.2016.01.007

Noroozi, O. (2017). The Effects of a Digital Dialogue Game on Higher Education Students' Argumentation-Based Learning. *International Journal of Educational and Pedagogical Sciences, 10*(12), 4062-4065. https://doi.org/10.5281/zenodo.1131027

Noroozi, O. (2018). Considering students' epistemic beliefs to facilitate their argumentative discourse and attitudinal change with a digital dialogue game. *Innovations in Education and Teaching International, 55*(3), 357-365. https://doi.org/10.1080/14703297.2016.1208112

Nousiainen, T., Kangas, M., Rikala, J., & Vesisenaho, M. (2018). Teacher competencies in game-based pedagogy. *Teaching and Teacher Education, 74*, 85-97. https://doi.org/10.1016/j.tate.2018.04.012

Ortega-Rodríguez, P. J., Gómez-García, M., Boumadan, M., & Soto-Varela, R. (2022). Media literacy of university students for creating digital contents. *Innoeduca. International Journal of Technology and Educational Innovation, 8*(2), 69-82. https://doi.org/10.24310/innoeduca.2022.v8i2.14169

Perini, S., Luglietti, R., Margoudi, M., Oliveira, M., & Taisch, M. (2018). Learning and motivational effects of digital game-based learning (DGBL) for manufacturing education–The Life Cycle Assessment (LCA) game. *Computers in Industry, 102*, 40-49. https://doi.org/10.1016/j.compind.2018.08.005

Pinto, A., Pérez-Garcias, A., & Darder, A. (2023). Training in teaching digital competence: functional validation of the TEP model. *Innoeduca Int J Technol Educ Innovation, 9*(1), 39-52. https://doi.org/10.24310/innoeduca.2023.v9i1.15191

Reynolds, R., & Caperton, I. (2011). Contrasts in student engagement, meaning-making, dislikes, and challenges in a discovery-based program of game design learning. *Educational Technology Research & Development, 59*(2), 267–289. http://dx.doi.org/10.1007/s11423-011-9191-8.

Rienties, B., Giesbers, B., Tempelaar, D., Lygo-Baker, S., Segers, M., & Gijselaers, W. (2012). The role of scaffolding and motivation in CSCL. *Computer & Education, 59*, 893–906. https://doi.org/10.1016/j.compedu.2012.04.010

Robertson, J., & Howells, C. (2008). Computer game design: opportunities for successful learning. *Computers & Education, 50*(2), 559–578. http://dx.doi.org/10.1016/j.compedu.2007.09.020.

Root-Bernstein, R., & Root-Bernstein, M. (1999). *Sparks of genius: The thirteen thinking tools of the world's most creative people.* Houghton Mifflin Co.

Sternberg, R. J. (2012). What is the purpose of schooling? In D. Ambrose, & R. J. Sternberg (Eds.), *How dogmatic beliefs harm creativity and higher level thinking* (pp. 207–219). Routledge: Taylor and Francis Group.

Sun, L., Ruokamo, H., Siklander, P., Li, B., & Devlin, K. (2021). Primary school students' perceptions of scaffolding in digital game-based learning in mathematics. *Learning, Culture and Social Interaction*, *28*, 1-11. https://doi.org/10.1016/j.lcsi.2020.100457

Sungur, N., (1988). *Yaratıcı Düşünce.* Özgür Yayın Dağıtım.

Torrance, E. P. (1972). Can we teach children to think creatively? *The Journal of Creative Behavior, 6*(2), 114-143. https://doi.org/10.1002/j.2162-6057.1972.tb00923.x

Tropper, N., Leiss, D., & Hänze, M. (2015). Teachers' temporary support and worked-out examples as elements of scaffolding in mathematical modeling. *ZDM Mathematics Education, 47*, 1225–1240. https://doi.org/10.1007/s11858-015-0718-z

Van de Pol, J., Volman, M., & Beishuizen, J. (2010). Scaffolding in teacher-student interaction: A decade of research. *Educational Psychology Review, 22*(3), 271–296. https://doi.org/10.1007/s10648-010-9127-6

Vos, N., Van Der Meijden, H., & Denessen, E. (2011). Effects of constructing versus playing an educational game on student motivation and deep learning strategy use. *Computers & education, 56*(1), 127-137. https://doi.org/10.1016/j.compedu.2010.08.013

Wainwright, A. M. (2014). Teaching historical theory through video games. *The History Teacher*, *47*(4), 579-612.

Watson, W. R., Mong, C. J., & Harris, C. A. (2011). A case study of the in-class use of a video game for teaching high school history. *Computers & Education, 56,* 466–474. https://doi.org/10.1016/j.compedu.2010.09.007

Wilson, G.M., Al-Jassim, M., Metzger, W.K., Glunz, S.W., Verlinden, P. et al. (2020). The 2020 photovoltaic technologies roadmap. *Journal of Physics D: Applied Physics 53*(49). https://doi.org/10.1088/1361-6463/ab9c6a

Wu, C.-H., Tzeng, Y.-L., & Huang, Y.-M. (2020). Measuring performance in leaning process of digital game-based learning and static E-learning. *Educational Technology Research and Development,* 68, 2215-2237. https://doi.org/10.1007/s11423-020-09765-6

Yıldırım, A. ve Şimşek, H. (2005). *Sosyal Bilimlerde Nitel Araştırma Yöntemleri.* Seçkin Yayıncılık.

Yu, Z. Yu, W.H. Fan, X. & Wang, X. (2014) An exploration of computer game-based ınstruction in the ''World History'' class in secondary education: A comparative study in China. *Plos One 9*(5), 1-7. https://doi.org/10.1371/journal.pone.0096865

Zin, N. A. M., Jaafar, A., & Yue, W. S. (2009). Digital game-based learning (DGBL) model and development methodology for teaching history. *WSEAS transactions on computers, 8*(2), 322-333.

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Teachers' acceptance of technology-based simulation games as teaching pedagogy in management education: an extended technology acceptance model

Aceptación de los docentes de los juegos de simulación basados en tecnología como pedagogía docente en la educación gerencial: un modelo extendido de aceptación de la tecnología

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ABSTRACT

The present study investigates the factors underlying the adoption of technology-based simulation games (SGs) by teachers in the formal management education. The proposed framework is an integration of the widely used Technology Acceptance Model (TAM); two institutional factors namely, top management support and training; and one individual factor, i.e. self-efficacy. The proposed model was empirically tested using a sample of 311 teachers selected using convenience sampling from the Indian management institutions. The primary data was gathered through surveys of teachers from business and management schools in India. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to test the proposed model. This study has found that the three external variables, i.e. top management support, training opportunities and self-efficacy, have direct influence on the two constructs of TAM (i.e. perceived usefulness and perceived ease of use), and have indirect influence on adoption intention of simulation games. The findings of this study have relevance to the SG developers as well as the top authorities / management of business schools. The findings suggest that SG developers must concentrate on creating the solutions that fit well with the teachers' current pedagogies. Moreover, the management of business schools provide adequate training and support to their teachers to promote the adoption of SGs. The study contributes to the literature by putting forward the perceptions of management teachers within Indian contexts. By proposing an extended TAM model, the study has contributed to the knowledge of educational technology adoption in the context of technology-based simulations for teaching.

KEYWORDS Technology; simulation games; TAM; management education; teaching pedagogy.

RESUMEN

El presente estudio investiga los factores que subyacen a la adopción de juegos de simulación (SG) basados en tecnología por parte de profesores en la educación formal en gestión. El marco propuesto es una integración ampliada del Modelo de Aceptación de Tecnología (TAM); dos factores institucionales, a saber, el apoyo y la formación de la alta dirección; y un factor individual, es decir, la autoeficacia. El modelo propuesto se probó empíricamente utilizando una muestra de 311 docentes seleccionados mediante muestreo por conveniencia de las instituciones de gestión de la India. Los datos primarios se recopilaron a través de encuestas a profesores de escuelas de negocios y administración de la India. Se utilizó el modelo de ecuaciones estructurales de mínimos cuadrados parciales (PLS-SEM) para probar el modelo propuesto. Este estudio ha encontrado que las tres variables externas, es decir, el apoyo de la alta dirección, las oportunidades de capacitación y la autoeficacia, tienen influencia directa en los dos constructos de TAM (es decir, utilidad percibida y facilidad de uso percibida), y tienen influencia indirecta en la intención de adopción de juegos de simulacion. Los hallazgos de este estudio son relevantes para los desarrolladores de SG, así como para las principales autoridades y direcciones de las escuelas de negocios. Los hallazgos sugieren que los desarrolladores de SG deben concentrarse en crear soluciones que se ajusten bien a las pedagogías actuales de los docentes. Además, la dirección de las escuelas de negocios proporciona formación y apoyo adecuados a sus profesores para promover la adopción de SG. El estudio contribuye a la literatura al presentar las percepciones de los profesores de gestión en contextos indios. Al proponer un modelo TAM extendido, el estudio ha contribuido al conocimiento de la adopción de tecnología educativa en el contexto de simulaciones basadas en tecnología para la enseñanza.

PALABRAS CLAVE Tecnología; juegos de simulación; TAM; educación gerencial; pedagogía de la enseñanza.

1. INTRODUCTION

The higher education programs in management have often been criticized for their pedagogical issues such as, disconnect of curriculum from management practice, teacher-directed learning with limited student engagement and knowledge sharing, and limited attention to developing affective, moral, critical thinking and problem-solving skills in students (Sierra, 2020). These issues can be addressed through incorporating student-centric experiential learning models in instructional methods. “Games and simulations” are amongst those active learning methodologies that can be aligned with several goals of management education (Al-Azawi et al., 2016; Dichev and Dicheva, 2017; López et al., 2021; Roungas et al., 2021). Educational games and simulations can engage students in solving complex and dynamic management problems through applying job-relevant knowledge and skills (Lu et al., 2014; Sierra, 2020) and gaming elements positively affect their motivation and attitude (Galiç & Yıldız, 2023).

Recent technological advances have led to the development of computer-based simulation games (SGs) that make use of innovative technologies such as artificial intelligence, virtual reality, and augmented reality. SGs based on such technologies have increased levels of authenticity, flexibility, immediacy, realism, and engagement (Krath et al., 2021; McGarr, 2020). These SGs provide an artificial reproduction of a reality where learners use their knowledge and skills to solve a problem in the virtual world (Pasin & Giroux, 2011). SG based learning can not only address the cognitive and affective learning issues but can also facilitate interactivity and collaboration (Jean Justice & Ritzhaupt, 2015; Lu et al., 2014). Because of the numerous benefits of SGs, management and business schools have been looking for such solutions to create a new

learning environment that better corresponds with the habits and interests of their students (Koutska, 2023). However, previous research has found that adoption of SGs in formal educational programs has been slow, as it requires expensive resources, advanced facilities, and trained teachers / faculty members (Kim & Watson 2017). The adoption of such educational technologies is especially challenging in Asian countries, which lack educational technology infrastructure and human capacity to implement modern educational strategies (Dede, 2018). Though studies in the past have tried to identify the barriers in the acceptance of SGs (Siala et al., 2020; Watson & Yang, 2016), however there is a dearth of empirical studies taking a broad enough approach to identify the influencing factors of adopting technology-based SGs in management education within the context of Asian countries (Jean Justice & Ritzhaupt, 2015). Moreover, even though teachers are primary agents in introducing innovative educational methods, previous research has neglected the role of teachers in integrating SGs with education (Jong & Shang, 2015).

Hence, the present study proposes a model of factors that influence the adoption of technology-based SGs by management teachers in India. The proposed framework is an integration of the widely used Technology Acceptance Model (TAM; Davis, 1989); two institutional factors namely, top management support and training; and one individual factor, i.e. self-efficacy. The study makes two worthwhile contributions to the literature. First, it addresses the barriers to the adoption of SGs in Indian management institutions, which is an under researched area. Second, by integrating the TAM with individual and institutional characteristics, the study addresses the calls by previous researches to extend TAM in educational contexts (Mailizar et al., 2021).

The paper is organized as follows: The theoretical background of the study is discussed in section 2 and, the conceptual framework of the study along with hypotheses development are discussed in section 3. The research design and data collection procedure are discussed in section 4. Section 5 presents the data analysis and results. Further, results have been discussed in section 6 followed by conclusion and limitations of the study in section 7.

1.1. Theoretical background

1.1.1. Conceptualizing SGs

Simulation is an educational tool that reproduces the real-life situations of an event. Educational simulations can be broadly classified into two categories: non-computer-based and computer-based (López, et al., 2021). Non-computer-based simulations involve manual exercises, games and physical interactions among the students that are constrained by a fixed set of rules and procedures. On the other hand, computer-based simulations make use of computers and technology to replicate system characteristics (Hinck & Ahmed, 2015). For example, training simulations (such as flight simulators) are used to imitate real-world processes to improve performance of the user in accomplishing a certain task, whereas modeling simulations (such as weather simulations or car modeling) are used to model processes or objects to test and/or create a model (De Smale et al., 2016). Simulation games are goal-oriented imitation of real-world processes that may be played against a computer model (single-user application), or against other users through a computer application (multi-user application) (Hinck & Ahmed, 2015). They allow learners to learn in a more enjoyable and interactive way by using technology-based resources in a scenario-based environment (López, et al., 2021).

SGs in management education

The SGs used in management education create a dynamic team learning environment integrating three components: (1) a computer-coded business simulator; (2) a team of students (participants) who compete through interaction and decision-making; and (3) an administrator (teacher) who directs and observes the students' behavior (Hinck & Ahmed, 2015). The students in a SG play in a virtual environment, wherein they employ budgeted resources (such as money, time, personnel) to achieve specific goals related to sales, productivity, or market share (Lu et al., 2014). Research into SGs suggest that they provide a valid representation of real-world issues to the learners, integrating a wide range of management concepts and tools (Hinck & Ahmed, 2015). The students can acquire necessary management skills through SGs, such as strategy formulation, problem solving, communication skills, team work, and analysis of multiple variables (López, et al., 2021). Most authors agree that SGs help in improving learning outcomes (Ahmed & Sutton, 2017).

1.1.2. Teachers' perceptions on adopting SGs

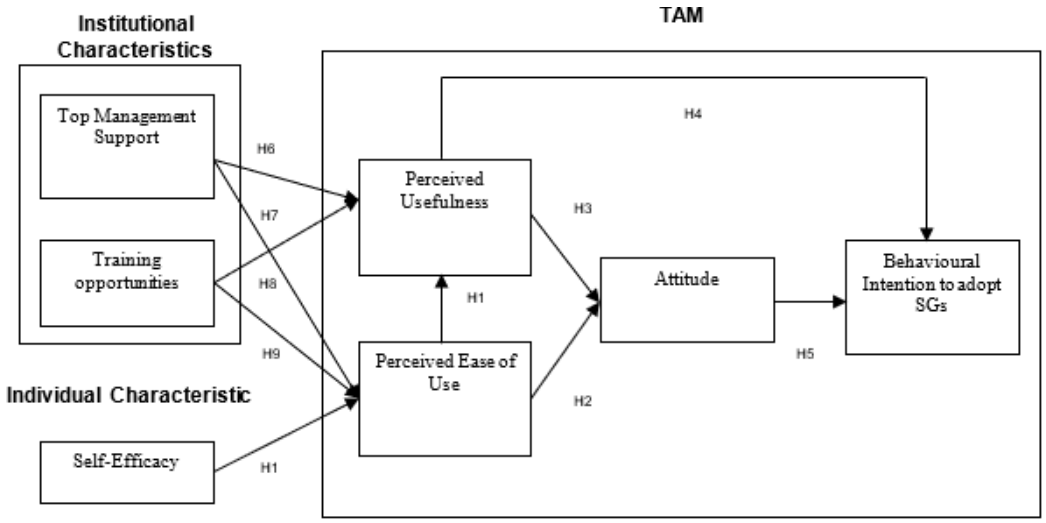
Jean Justice and Ritzhaupt (2015) developed an instrument to measure teacher perceived barriers to adopting SGs in education. They categorized the barriers into seven categories namely, negative student outcomes; technology issues; SG specific issues; issues related to teachers; incorporation issues; limited student abilities; and issues related to justifying the use of SGs in education. Vos and Brennan (2010) have studied the perceptions of marketing management teachers regarding the barriers to using SGs. The authors conclude that financial cost, administrative work-load concerns, and necessary skills for using SGs, are the major barriers to adopting SGs. The teachers face difficulties in obtaining permissions form institutional authorities to make investment in expensive SGs (Vos & Brennan, 2010). They also require time to learn a SG prior to using it as a pedagogical tool in classrooms (Vos and Brennan, 2010). Administrative support in terms of time and training have been cited by several researchers as a barrier to the adoption of SGs in education (Watson & Yang, 2016). According to Dimitriadou et al. (2021), lack of time, lack of resources and lack of administrative support are major obstacles to the adoption of SGs in education.

To sum up, most of the existing studies have emphasized on the barriers to adopt SGs in education. There is a dearth of empirical studies that can identify the factors that determine teachers' adoption of SGs. The present study attempts to fill this gap by taking a broad approach to identify the predictors of teachers' intention to adopt SGs in management education. We propose a framework based on widely used TAM (Davis, 1989). Because of its straightforwardness and good explanatory power, TAM has been a dominant model for investigating users' technology acceptance behavior in different organizational contexts (Rahman et al., 2017). TAM has been largely used in the education sector to understand the teacher's intention to adopt new educational technologies (Pando-Garcia et al. 2016; Sharma & Srivastava; 2019; Saroia & Gao, 2019; Wu & Chen, 2017). Nevertheless, researchers have found certain limitations in TAM because of its restricted constructs. TAM has been critiqued for its inability to include the determinants of its two major constructs i.e. perceived usefulness and perceived ease of use variables (Malatji et al., 2020). It is therefore advised to extend TAM with other external factors depending on the context of the study (Ajibade, 2018). Hence, we propose an integrated model that extends TAM with two institutional characteristics (namely, top management support and training opportunities), and one individual characteristic (namely, self-efficacy), to study the management teachers' intention to adopt SGs.

1.2. Conceptual framework

The proposed framework is depicted in Fig. 1. Based on the proposed research model, nine hypotheses have been developed as discussed below.

FIGURE 1. Proposed framework



1.2.1. Hypotheses related to TAM variables

The TAM (Davis, 1989) includes four constructs namely, behavioural intention (BI) to adopt a technology, attitude (ATT) towards technology usage, perceived usefulness (PU) and perceived ease of use (PEoU). In this study, BI is defined as the degree to which teachers are inclined to adopt SGs in management education. ATT is defined as the degree that measures teachers' interests in using SGs. PU is defined as the degree to which teachers believe that using SGs will enhance their teaching performance. PEoU refers to the degree to which teachers expect that using SGs is free of effort.

The following relationships between the TAM constructs have been included in the original TAM (Davis, 1989): PU is positively influenced by PEOU; ATT is positively influenced by both PU and PEOU; and BI is positively influenced by ATT as well as PU. These relationships have been tested in previous studies for explaining the adoption of technologies in different educational contexts, such as virtual reality (Sagnier et al., 2020) Cloud based virtual reality (Sayginer, 2023), mobile learning management systems (Saroia & Gao, 2019), virtual reality simulation (Fagan et al., 2012), and Massive Open Online Courses (Wu & Chen, 2017). Rafique et al. (2023) found that PEoU is a very strong determinant of teachers' intention to use e-learning technology. Pando-Prior studies have confirmed that confirmed that PEoU and PU strongly determine the attitude to use business simulation games (Pando-Garcia et al., 2016) and micro-games (Wijaya et al., 2022a), which in turn determines the intention to use the same. Thus, we propose the following hypotheses.

H1: PEoU has a significant positive influence on PU of SGs

H2: PEoU has a significant positive influence on ATT towards using SGs

H3: PU has a significant positive influence on ATT towards using SGs

H4: PU has a significant positive influence on BI to adopt SGs

H5: ATT has a significant positive influence on BI to adopt SGs

1.2.2. Hypotheses related to external variables

Top management support

According to Hsu et al. (2019), top management support (TMS) refers to the beliefs of top authorities regarding the usefulness of a technology or innovation, in creating value for their organization. It ensures a long-term vision, commitment of resources required for using the innovation, as well as an organization climate that is supportive of using the innovation (Gupta & Bhaskar, 2023). Within the educational contexts, Saroia and Gao (2019) argued for positive influence of TMS on PU and PEoU of mobile learning management systems. Iqbal and Bhatti (2017) also highlighted the importance of TMS for innovative learning initiatives. The authors also concluded that TMS has significant positive impacts on students' perceptions of PEOU and PU of innovative educational technologies. Thus, the present study hypothesizes that TMS (in terms of availability of resources, time and technical assistance) will positively influence the teachers' perceptions regarding PEoU and PU of SGs. Hence, the following hypotheses are proposed:

H6: TMS has a significant positive influence on PU of SGs

H7: TMS has a significant positive influence on PEoU of SGs

Training opportunities

Training refers to the degree to which an organization trains its employees for using a tool/ technology/ innovation. Training is helpful in reducing employees' stress and ambiguity about the use of a technology (Gangwar et al., 2015). Since teachers may find difficulties in incorporating SGs in their teaching pedagogy, the institutions should provide opportunities to train and educate them regarding the usage of SGs (Sánchez-Mena & Martí-Parreño, 2017). Training provides a better understanding about the benefits of SGs and reduces teachers' anxiety about the use of SGs (Vlachopoulos & Makri, 2017). Gangwar and Date (2015) confirmed that training positively influences the PEoU and PU of a technology. For the present study, we hypothesize that training opportunities (TO) will help teachers develop knowledge about SGs as well as make effective use of SGs. Thus, the following hypotheses are postulated:

H8: TO has a significant positive influence on PU of SGs

H9: TO has a significant positive influence on PEoU of SGs

Self-efficacy

Self-efficacy (SE) is a measurement of an individual's capability to perform a task (Zhi et al., 2023). For the present study, self-efficacy is considered to include a teacher's general skills and capabilities that are required to accomplish the tasks related to SGs. Recent research indicates that computer self-efficacy significantly determines PEoU of a technology (Ali & Warraich, 2023). Within the educational contexts, self-efficacy has been found to indirectly affect teachers' intentions via PEoU (Joo et al., 2018). Eraslan Yalcin and Kutlu

(2019) found a significant impact of computer self-efficacy on PEoU. Sharma and Saini (2022) found that teachers with high self-efficacy feel less anxious about using educational technologies in classrooms. Also, Guillén-Gámez et.al., (2021) noted that age and gender also affect the digital competence of the educae tors. Since, teachers require basic technical and quantitative skills for using SGs, hence we hypothesize that teachers with high SE will find SGs easy to use. Thus, we propose the following hypothesis:

H10: SE has a significant positive influence on PEoU of SGs

2. MATERIAL AND METHOD

2.1. Design and Sample

The present study employed an analytical cross-sectional research design, wherein the primary data was collected through a survey that was carried out during January-February 2023. The cross-sectional research designs are useful for exploring the relationships between various variables (Kesmodel, 2018). Teachers from business schools or management/business studies departments of universities in India, who have used SGs at least once in their classes, were the target respondents of the study. As per the National Institutional Ranking Framework (NIRF) of India, there are 75 business/management schools/institutions in various states of India (National Institutional Ranking Framework, 2021). These 75 institutions served as the target population for the current study. A non-random sampling technique i.e. convenience sampling was used to select the target respondents from these 75 institutions. A total of 500 teachers were contacted using convenience sampling to fill in the paper-based/online questionnaires, out of which 341 questionnaires were returned. After removing the unviable responses, a total of 311 usable questionnaires were. Table 1 illustrates the respondents' characteristics for both the samples as well as the combined sample.

TABLE 1. Sample Profile

RESPONDENT'S CHARACTERISTIC	CATEGORIES	Combined Sample (n=311)	
		n	%
Gender	Male	154	49.5%
	Female	157	50.5%
Teaching experience	<= 10 years	140	45.0%
	11 years - 20 years	98	31.5%
	>= 20 years	73	23.5%
Academic department	Finance and Accounting	72	23.2%
	Marketing Management	95	30.5%
	Human Resource Management	39	12.5%
	Operations Management	15	4.8%
	Analytics	14	4.5%
	General Management	76	24.4%
Type of Institution	Government	121	38.9%
	Private	190	61.1%

2.2. Survey instrument

A structured questionnaire was used as the survey instrument. The questionnaire consisted of two parts. The first part included questions on respondents' demographic characteristics such as gender, years of teaching experience, academic department, and type of institution. The second part included 22 items to measure the seven research constructs used in this study. To ensure construct validity, the items used in the questionnaire were adapted from previous studies (Cheon et al., 2012; Pando-Garcia et al., 2016; Rajan & Baral, 2015; Sagnier et al., 2020). To fit the context of SGs, some minor word changes were made in the scale items. The questionnaire was pre-tested with 10 academics to ensure the face validity of items. The questions in the first part of the questionnaire were categorical (nominal), whereas the items in the second part were measured using a 7-point Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree).

2.3. Data analysis technique

We used the partial least squares structural equation modelling (PLS-SEM) to test the proposed model. PLS-SEM is a non-parametric technique, which is robust in the cases concerning distribution issues such as lack of normality (Hair et al., 2019). Moreover, it can also be used with small samples (Hair et al., 2019; Staples & Seddon, 2004). Hence, PLS-SEM is an appropriate technique for the present study. As recommended by Cohen (1992) and Hair et al. (2019), the sample size to perform PLS-SEM depends on the number of causal paths pointing towards an endogenous construct in the structural model. In this study, the maximum number of such paths is 3 (see Fig. 1), which requires a sample size of 59 to ensure a statistical power of 80% (Cohen, 1992; Hair et al., 2019). Our study sample met this criterion with a sample size of 311. The SmartPLS 4 software was used to perform PLS-SEM. The PLS-SEM was applied using a two-step approach that included the evaluation of measurement model followed by the estimation of structural model (Sarstedt & Cheah, 2019). The reliability and validity of the model constructs were established by evaluating the measurement model, and hypothesized relationships between the constructs were tested using the structural model (Guillén-Gámez et al., 2024; Liu et al., 2022; Wijaya et al., 2022b).

3. RESULTS

3.1. Descriptive statistics

Table 2 indicates the mean, standard deviation, skewness and kurtosis values of all the items. As can be observed from the table, the mean score for all the items was greater than 3 which indicates that the respondents provided positive responses for all the items. Further, the skewness and kurtosis values of all the items were within the threshold limits of 3 and 10 respectively (Moorthy et al., 2019), indicating univariate normality.

TABLE 2. Descriptive Statistics

CONSTRUCT	ITEM	MEAN	STANDARD DEVIATION	SKEWNESS	KURTOSIS
TMS	TMS1	3.66	0.959	-0.479	0.027
	TMS2	3.67	0.909	-0.332	-0.132
	TMS3	3.64	0.929	-0.440	0.195
TO	TO1	3.58	0.993	-0.530	0.111
	TO2	3.65	0.987	-0.442	-0.166
	TO3	3.57	0.996	-0.363	-0.323
SE	SE1	3.62	0.962	-0.418	-0.218
	SE2	3.67	0.992	-0.312	-0.419
	SE3	3.65	0.949	-0.289	-0.209
PEoU	PEoU1	3.86	0.948	-0.554	-0.203
	PEoU2	3.83	1.003	-0.630	-0.075
	PEoU3	3.86	0.969	-0.651	-0.161
PU	PU1	3.92	0.905	-0.815	0.682
	PU2	3.86	0.906	-0.507	-0.051
	PU3	3.92	0.888	-0.830	0.843
	PU4	3.93	0.915	-0.683	0.262
ATT	ATT1	3.90	0.968	-0.887	0.626
	ATT2	3.79	0.991	-0.709	0.072
	ATT3	3.78	0.987	-0.630	0.008
BI	BI1	3.79	0.913	-0.702	0.586
	BI2	3.73	0.938	-0.569	0.211
	BI3	3.76	0.968	-0.555	0.099

3.3. Measurement model

The reflective measurement model was examined to establish the reliability and validity of the latent constructs. Table 3 depicts the analysis of the measurement model for the combined sample. The item reliability was evaluated by examining the indicator loadings. Since all the indicator loadings (see Table 3) were greater than the recommended value of 0.708 (Hair et al., 2019), hence the item reliability was ensured. To assess the construct reliability, we examined the internal consistency reliability on the basis of composite reliability (CR) and Cronbach's alpha. The values of CR and Cronbach's alpha (see Table 2) for all the latent constructs fall in the acceptable range of 0.70 – 0.90, indicating that the constructs were reliable. Some researchers argue that βA is a more appropriate measure of construct reliability as compared to CR and Cronbach's alpha (Dijkstra & Henseler, 2015). An examination of the values of ρA (see Table 3) also confirmed the reliability of the constructs as the values lied between the lower bounds of Cronbach's alpha and upper bounds of CR (Hair et al., 2019). The convergent validity was assessed through the metric average variance extracted (AVE). The AVE value of each construct was higher than the recommend value of 0.50 (Hair et al., 2019), indicating that each construct explained more than 50 per cent of the variance of its corresponding items.

TABLE 3. Reliability and Validity

CONSTRUCT	ITEM	LOADING	T-STATISTIC	CRONBACH'S ALPHA	PA	CR	AVE
TMS	TMS1	0.89	56.82***	0.853	0.853	0.911	0.773
	TMS2	0.86	36.48***				
	TMS3	0.88	45.60***				
TO	TO1	0.85	38.77***	0.835	0.835	0.901	0.753
	TO2	0.86	34.40***				
	TO3	0.89	48.57***				
SE	SE1	0.88	53.68***	0.812	0.821	0.889	0.727
	SE2	0.82	27.50***				
	SE3	0.86	40.47***				
PEoU	PEoU1	0.89	72.17***	0.810	0.816	0.888	0.725
	PEoU2	0.87	46.45***				
	PEoU3	0.79	23.75***				
PU	PU1	0.83	33.17***	0.868	0.868	0.91	0.716
	PU2	0.85	36.28***				
	PU3	0.86	44.77***				
	PU4	0.84	43.84***				
ATT	ATT1	0.88	55.32***	0.833	0.834	0.9	0.75
	ATT2	0.85	38.25***				
	ATT3	0.87	40.39***				
BI	BI1	0.85	35.90***	0.805	0.805	0.885	0.719
	BI2	0.83	32.89***				
	BI3	0.86	47.85***				

To ensure that each construct was empirically distinct from the other constructs in the model, we assessed the discriminant validity. Following the criteria of Fornell and Larcker (1981), we compared each construct's AVE to its squared inter-construct correlations with all other constructs in the model. Table 4 illustrates the inter-construct correlations (off-diagonal elements) and the squared roots of AVEs (diagonal elements). The shared variance (inter-construct correlations) for all constructs were found to be lesser than the squared roots of their AVEs (see Table 4). Hence discriminant validity was ensured. We also examined the heterotrait-monotrait (HTMT) ratio of the correlations (Voorhees et al., 2016) to further ensure the discriminant validity. As the HMTT values (see Table 4) were lower than the suggested threshold of 0.90 (Henseler et al., 2016), discriminant validity problems were not present.

TABLE 4. Discriminant Validity

FORNELL AND LARCKER (1981) CRITERION							
	ATT	BI	PEoU	PU	SE	TMS	TO
ATT	0.866						
BI	0.749	0.848					
PEoU	0.682	0.707	0.852				
PU	0.716	0.782	0.733	0.846			
SE	0.474	0.636	0.543	0.552	0.853		
TMS	0.487	0.571	0.498	0.524	0.541	0.879	
TO	0.552	0.662	0.562	0.62	0.554	0.529	0.867
HTMT RATIOS							
	ATT	BI	PEOU	PU	SE	TMS	TO
ATT							
BI	0.815						
PEOU	0.828	0.842					
PU	0.840	0.834	0.832				
SE	0.574	0.785	0.666	0.654			
TMS	0.577	0.687	0.600	0.608	0.650		
TO	0.660	0.807	0.682	0.726	0.670	0.626	

3.4. Structural Model

Following the recommendations of Henseler et al. (2016), we assessed the structural model through five steps including - multicollinearity analysis; path analysis; coefficient of determination (R2); effect sizes(f2); and predictive power. Each of these steps are discussed below.

1. Collinearity: The collinearity was examined through variance inflation factor (VIF) values, to ensure the unbiasedness of the regression results (Kock, 2015). The VIF values (see Table 4) of the predictor constructs were lower than 3, indicating the absence of collinearity issues (Hair et al., 2019).
2. Path analysis: The significance levels for the paths in the structural model were estimated through bootstrapping with 2000 resamples. Table 5 provides the path coefficients (β) for the samples. The path coefficients for the overall sample provide support for all the hypotheses. Specifically, the analysis can be summarized as follows: PEoU has a statistically significant positive influence on PU (β=0.526, p<0.001) thus confirming hypothesis H1. Both PEoU (β=0.341, p<0.01) and PU (β=0.465, p<0.001) carry significant influence on ATT thus supporting hypotheses H2 and H3. The results also show that PU is more important construct than PEoU in explaining ATT. The results further indicate that PU (β=0.504, p<0.001) and (β=0.389, p<0.001) ATT significantly influence BI, with PU having stronger influence. Hence H4 and H5 are also supported. With regards to the institutional characteristics, TMS is found to have significant positive influence on both PU (β0.127, p<0.05) and PEoU (β=0.185, p<0.05). Similarly, TO is found to have significant positive influence on both PU (β=0.257, p<0.001) and PEoU (β=0.317, p<0.001). Hence the hypotheses H6 – H9 are supported. The results also indicate that both TMS and

TO are able to explain PEoU more than PU. Finally, the influence of the individual characteristic i.e. SE on PEoU (β=0.267, p<0.001) is also found to be significant.

We also examined the significance of indirect paths in the model. Table 5 illustrates the indirect path coefficients along with their significance. The results provide support for the significance of all the indirect paths. Specifically, PEoU (β=0.494, p<0.001) is found to be the strongest indirect influencer of BI, that is followed by TO (β=0.331, p<0.001), TMS (β=0.179, p<0.001) and SE (β=0.133, p<0.001). This indicates that BI is not only directly determined by ATT and PU, but also influenced indirectly by TO, TMS and SE. TO (β=0.304, p<0.001) is found to be the strongest indirect influencer of ATT, that is followed by TMS (β=0.169, p<0.001) and SE (β=0.156, p<0.001). SE (β=0.142, p<0.001) is found to be the strongest indirect influencer of PU, that is followed by TO (β=0.164, p<0.001) and TMS (β=0.098, p<0.01). The significant results of the indirect effects indicate that the institutional characteristics (i.e., TMS and TO) and individual characteristic (i.e. SE) are indirect determinants of ATT as well as BI. This provides support for the extension of TAM with the individual and institutional characteristics.

TABLE 5. Path Coefficients

HYPOTHESIS	PATH	β	t-statistic	VIF	RESULT	f2
H1	PEoU → PU	0.526	10.705***	1.592	Supported	1.39
H2	PEoU → ATT	0.341	3.468**	2.164	Supported	0.39
H3	PU → ATT	0.465	6.233***	2.164	Supported	1.56
H4	PU → BI	0.504	6.878***	2.049	Supported	1.27
H5	ATTU → BI	0.389	5.148***	2.049	Supported	0.16
H6	TMSU → PU	0.127	2.531*	1.511	Supported	0.10
H7	TMSU → PEoU	0.185	3.131*	1.584	Supported	0.03
H8	TOU → PU	0.257	5.102***	1.662	Supported	0.02
H9	TOU → PEoU	0.317	4.617***	1.615	Supported	0.01
H10	SEU → PEoU	0.267	4.22***	1.646	Supported	0.10

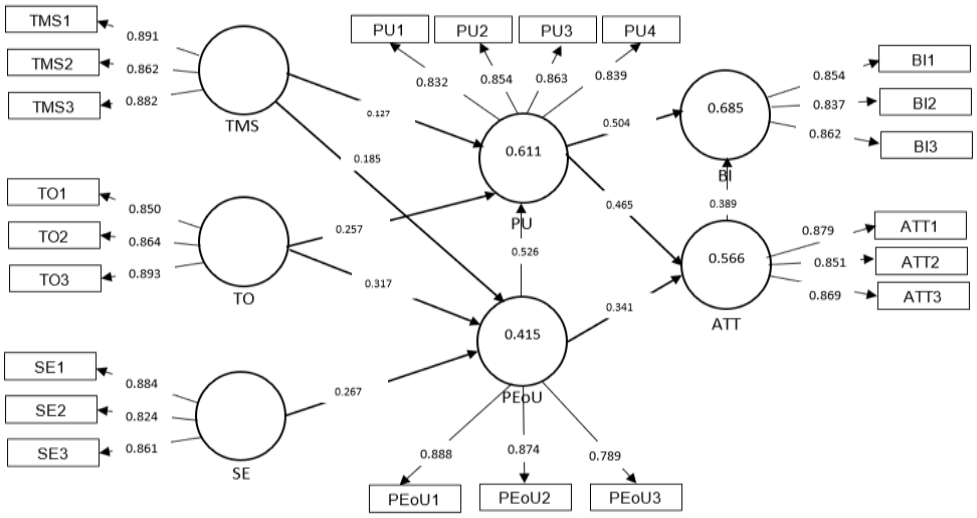
Note: *p<0.05; **p<0.01; ***p<0.001

TABLE 6. Indirect effects

PATH	β	t-statistic
PEoU → BI	0.494	11.201***
SE → ATT	0.156	4.028***
SE → BI	0.133	3.879***
SE → PU	0.142	3.605***
TMS → ATT	0.169	3.600***
TMS → BI	0.179	3.651***
TO → ATT	0.304	5.688***
TO → BI	0.331	6.028***

3. Coefficient of determination (R2): This coefficient indicates the variance explained by the predictor variables (exogeneous variables) in an endogenous variable. R2 values at the threshold of 0.25, 0.50 and 0.75 indicate weak, moderate, and substantial levels (Hair et al., 2019). Our model (see Fig. 2) explained moderate to substantial variance in the endogenous constructs: PEoU (R2=41.5%), PU (R2=61.1%), ATT (R2=56.6%) and BI (R2=68.5%).
4. Effect size (f2): To assess the strength of the hypothesized relationships, the effect sizes (f2) were calculated. According to Cohen (2013), f2 ≥ 0.02, f2 ≥ 0.15, and f2 ≥ 0.35 represent small, medium, and large effect sizes. Table 4 indicates the effect sizes for each relationship.
5. Predictive power: The model's predictive accuracy was also assessed by Stone-Geisser criterion Q2 criteria (Geisser, 1975). According to Hair et al. (2019), Q2 values above zero indicate that the model has predictive relevance. According to Guillén-Gámez et al. (2024), the Q2 values of 0.02, 0.15, and 0.35 are indicative of small, medium and large predictive powers. Our results revealed that the predictive relevance was medium to large for all the endogenous constructs: PEoU (Q2=28.8%), PU (Q2=42.7%), AT (Q2=41.3%) and BI (Q2=48.2%).

FIGURE 2. Structural model with R^2 values



4. DISCUSSION

This research analyzed teachers' intention to adopt technology-based simulation games in management education, based on the data collected from India. The study proposed a modified model of factors by extending the TAM with two institutional factors (i.e. top management support and training) and one individual factor (i.e. self-efficacy). Our study has found support for all the proposed hypotheses.

4.1. Perceived usefulness and attitude positively influence teachers' intention to adopt simulation games

Specifically, the findings of our study argue for strong roles of perceived usefulness and attitude in determining teachers' intention to adopt simulation games. The findings are consistent with Zulfikar et.al (2021) and Pongpanich et al. (2009) who found usefulness to be the primary reason of using simulation games in classrooms. One of the reasons for not using simulation games is their lack of usefulness or poor fit with the courses being taught (Jääskä & Aaltonen, 2022). Management teachers generally have concerns about the ability of simulation games to facilitate the teaching process (Vos & Brennan, 2010). The teachers use a simulation game while teaching a course, when they feel that it will help them achieve the learning outcomes. The perception that simulation games can enhance their teaching effectiveness, develops a positive attitude in them, and hence they become more inclined towards adopting them.

4.2. Perceived ease of use and perceived usefulness influence teachers' attitude and their intention to adopt simulation games

The findings also argue for a significant impact of perceived ease of use on perceived usefulness as well as teachers' attitude. The same results were derived in the original TAM studies (Davis, 1989; Venkatesh & Davis, 1996). The findings are also in line with Fagan et al. (2012) who found that perceived ease of use significantly predicts the perceived usefulness of virtual reality simulation. The findings also indicate that perceived ease of use is a strong indirect predictor of teachers' intention to adopt simulation games. This finding is in line with that of Vos and Brennan (2010) who found that lack of necessary skills among marketing lecturers is a key barrier to adopt simulation games. Management teachers are generally not very tech-savvy because of which they may find difficulty in using technology-based simulation games. In a survey carried out by Jääskä and Aaltonen (2021), it was found that majority of the teachers stopped using business simulation games because of the requirement of long preparation time. Hence, the management teachers are more likely to adopt simulation games if they feel that they can easily become skillful at using them.

4.3. Training opportunities positively influence perceived ease of use and perceived usefulness of simulation games

With regards to the external variables, training has been found to be a strong determinant of perceived usefulness as well as perceived ease of use. It is also being observed as an indirect determinant of teachers' attitude and their intention to adopt simulation games. This implies that if teachers get enough training on the simulation games, they will understand their educational benefits and hence will be more likely to adopt them. Training can also help them in becoming skillful at using simulation games. Vos and Brennan (2010) opined that management teachers find searching for and evaluating relevant simulation games to be a cumbersome and time-consuming process. Lack of information on simulation games acts as a significant barrier for the teachers in business schools to adopt them as teaching tools (Beuk 2016; Lester et.al 2023). Proper training can familiarize teachers with the simulation games and their learning benefits. Hence training can develop a positive attitude towards simulation games which can in turn motivate teachers to adopt them.

4.4. Top management support positively influences perceived ease of use and perceived usefulness of simulation games

Top management support has also been found to be a direct determinant of perceived usefulness and perceived ease of use, as well as an indirect predictor teachers' attitude and their intention to adopt simulation games. This implies that top management of educational institutions plays an effective role in convincing and motivating their teachers to adopt innovative technology-based teaching pedagogies. The findings are in line with the previous research (Beuk 2016; Dale et.al, 2021) that have highlighted the lack of institutional support (in terms of resources and time) as one of the key barriers in adopting simulation games in business schools. Teachers in higher educational institutions are generally under pressure to meet the growing expectations of research, because of which they find it difficult to take out time for learning new teaching techniques (Lester et al., 2021; Jääskä & Aaltonen, 2022). Top management's commitment and continuous support (such as providing necessary infrastructure, monetary support, administrative support and time) helps in developing conducive environment for adoption of simulation games.

4.5. Self-efficacy positively influences perceived ease of use

The findings further indicate significant direct influence of teachers' self-efficacy on perceived ease of use. Teachers' who are well versed with digital skills find simulation games easy to use. Their technical capabilities make them confident in integrating technology-based simulation games with their traditional teaching methods. The findings also suggest significant indirect effects of teachers' self-efficacy on perceived usefulness, attitude and intention to adopt simulation games. However, the indirect effects are relatively weak as compared to other variables viz. top management support and training opportunities. The findings are in line with those of Pongpanich et al. (2009) and Faria and Wellington (2004) that indicate technical issues as a less important reason for not using simulation games in business schools.

5. CONCLUSIONS

Because of their numerous learning benefits, simulation games are widely used in business and management programmes. With the advent of new technologies such as artificial intelligence, virtual reality, augmented reality and hybrid reality, technology-based simulation games are gaining popularity because of their flexibility, realism, and engagement. This study's main purpose was to investigate the factors affecting adoption of technology-based simulation games by teachers in business schools. In order to explore the influencing factors, the study extended the widely used TAM framework with two institutional factors namely, top management support and training; and one individual factor, i.e. self-efficacy. The findings indicated that teachers' behavioural intention to adopt simulation games was determined by the perceived usefulness of simulation games and their attitude towards the simulation games. The findings further indicated that teachers' attitude was determined by the perceived ease of use and perceived usefulness of simulation games. It was also found that the top management support and training opportunities provided by the educational institutions significantly influenced the teachers' perceptions of usefulness and ease of using simulation games. Moreover, teachers' self-efficacy was also found to be a significant determinant of their perceptions of the ease of using simulation games.

Premised in India, the study contributed to the literature by putting forward the perceptions of management teachers within Indian contexts. Given the challenges of India pertaining to the infrastructural resources, the present study tried to highlight the key concerned areas of the adoption of business simulation games in management education. The study contributed to the better understanding of viewpoints of teachers, who play pivotal role in introducing innovative technology-based teaching techniques in classrooms. By proposing an extended TAM model, the study contributed to the knowledge of educational technology adoption regarding technology-based simulations for teaching.

5.1. Limitations and future lines of research

This study has limitations with regards to the usage of limited set of variables in the proposed model. Future research may consider including other factors such as compatibility issues, personal innovativeness of teachers, and other environmental factors viz. social influence and subjective norms. Another direction for further research could be to investigate the perceptions of top management of business schools regarding the integration of technology-based simulation games in teaching and learning processes. A qualitative research using in-depth interviews of top management / decision makers can be conducted to understand the challenges and driving forces of adopting simulation games based on innovative technologies in formal management education.

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7. REFERENCES

Ahmed, A., & Sutton, M. J. (2017). Gamification, serious games, simulations, and immersive learning environments in knowledge management initiatives. *World Journal of Science, Technology and Sustainable Development*, *14*(2/3), 78-83. https://doi.org/10.1108/WJSTSD-02-2017-0005

Ajibade, P. (2018). Technology acceptance model limitations and criticisms: Exploring the practical applications and use in technology-related studies, mixed-method, and qualitative researches. *Library Philosophy and Practice*, *9, 1-13*.

Al-Azawi, R., Al-Obaidy, M., Ayesh, A., & Rosenburg, D. (2016, November). The impact of using educational gamification in mobile computing course: A case study. In *Communication, Management and Information Technology: International Conference on Communciation, Management and Information Technology* (pp. 235-241). CRC Press.

Ali, I., & Warraich, N. F. (2023). Impact of personal innovativeness, perceived smartphone ease of use and mobile self-efficacy on smartphone-based personal information management practices. *The Electronic Library*, *41*(4), 419-437. https://doi.org/10.1108/EL-12-2022-0262

Beuk, F. (2016). Sales simulation games: Student and instructor perceptions. *Journal of Marketing Education, 38*(3), 170-182. https://doi.org/10.1177/0273475315604686

Cheon, J., Lee, S., Crooks, S. M., & Song, J. (2012). An investigation of mobile learning readiness in higher education based on the theory of planned behavior. *Computers & education*, *59*(3), 1054-1064. https://doi.org/10.1016/j.compedu.2012.04.015

Cohen, J. (1992). Statistical power analysis. *Current directions in psychological science*, *1*(3), 98-101. https://doi.org/10.1111/1467-8721.ep10768783

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic press.

Dale, V., McEwan, M., & Bohan, J. (2021). Early adopters versus the majority: Characteristics and implications for academic development and institutional change. *Journal of Perspectives in Applied Academic Practice*, *9*(2), 54-67. https://doi.org/10.14297/jpaap.v9i2.483

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340. https://doi.org/10.2307/249008

De Smale, S., Overmans, T., Jeuring, J., & van de Grint, L. (2016). The effect of simulations and games on learning objectives in tertiary education: A systematic review. In *Games and Learning Alliance: 4th International Conference, GALA 2015* (pp. 506-516). Springer International Publishing. https://doi.org/10.1007/978-3-319-40216-1_55

Dede, C. (2018). *The Potential of Digital Game-Based Learning for Improving Education in the Global South.* Foundation for Information Technology Education and Development.

Dichev, C., & Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International journal of educational technology in higher education*, *14*(1), 1-36. https://doi.org/10.1186/s41239-017-0042-5

Dijkstra, T. K., & Henseler, J. (2015). Consistent partial least squares path modeling. *MIS quarterly*, *39*(2), 297-316. http://dx.doi.org/10.25300/MISQ/2015/39.2.02

Dimitriadou, A., Djafarova, N., Turetken, O., Verkuyl, M., & Ferworn, A. (2021). Challenges in serious game design and development: Educators' experiences. *Simulation & Gaming*, *52*(2), 132-152. https://doi.org/10.1177/1046878120944197

Eraslan Yalcin, M., & Kutlu, B. (2019). Examination of students' acceptance of and intention to use learning management systems using extended TAM. *British Journal of Educational Technology*, *50*(5), 2414-2432. https://doi.org/10.1111/bjet.12798

Fagan, M., Kilmon, C., & Pandey, V. (2012). Exploring the adoption of a virtual reality simulation: The role of perceived ease of use, perceived usefulness and personal innovativeness. *Campus-Wide Information Systems*, *29*(2), 117-127. https://doi.org/10.1108/10650741211212368

Faria, A. J., & Wellington, W. J. (2004). A survey of simulation game users, former-users, and never-users. *Simulation & Gaming, 35*(2), 178–207. https://doi.org/10.1177/1046878104263543

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of marketing research*, *18*(1), 39-50. https://doi.org/10.2307/3151312

Galiç, S., & Yıldız, B. (2023). The Effects of Activities Enriched with Game Elements in Mathematics Lessons. *Innoeduca. International Journal of Technology and Educational Innovation*, *9*(1), 67–80. https://doi.org/10.24310/innoeduca.2023.v9i1.15396

Gangwar, H., Date, H., & Ramaswamy, R. (2015). Understanding determinants of cloud computing adoption using an integrated TAM-TOE model. *Journal of enterprise information management*, *28*(1), 107-130. https://doi.org/10.1108/JEIM-08-2013-0065

Geisser, S. (1975). The predictive sample reuse method with applications. *Journal of the American statistical Association*, *70*(350), 320-328. https://doi.org/10.2307/2285815

Guillén-Gámez, F. D., Gómez-García, M., & Ruíz-Palmero, J. (2024). Competencia digital en labores de Investigación: predictores que influyen en función del tipo de universidad y sexo del profesorado. *Pixel-Bit: Revista de medios y educación*, (69), 7-34. https://doi.org/10.12795/pixelbit.99992

Guillén-Gámez, F. D., Mayorga-Fernández, M., Bravo-Agapito, J., & Escribano-Ortiz, D. (2021). Analysis of teachers' pedagogical digital competence: Identification of factors predicting their acquisition. *Technology, Knowledge and Learning, 26*(3), 481-498. https://doi.org/10.1007/s10758-019-09432-7

Gupta, K. P., & Bhaskar, P. (2023). Teachers' intention to adopt virtual reality technology in management education. *International Journal of Learning and Change*, *15*(1), 28-50. https://doi.org/10.1504/IJLC.2023.127719

Hair, J. F., Risher, J. J., Sarstedt, M., & Ringle, C. M. (2019). When to use and how to report the results of PLS-SEM. *European*

business review, *31*(1), 2-24. https://doi.org/10.1108/EBR-11-2018-0203

Henseler, J., Ringle, C. M., & Sarstedt, M. (2016). Testing measurement invariance of composites using partial least squares. *International marketing review*, *33*(3), 405-431. https://doi.org/10.1108/IMR-09-2014-0304

Hinck, W., & Ahmed, Z. U. (2015). The effect of anticipatory emotions on students' performance in marketing simulations. *Journal of Research in Marketing and Entrepreneurship*, *17*(1), 5-22. https://doi.org/10.1108/JRME-12-2014-0034

Hsu, H. Y., Liu, F. H., Tsou, H. T., & Chen, L. J. (2019). Openness of technology adoption, top management support and service innovation: a social innovation perspective. *Journal of Business & Industrial Marketing*, *34*(3), 575-590. https://doi.org/10.1108/JBIM-03-2017-0068

Iqbal, S., & Bhatti, Z. A. (2017). What drives m-learning? An empirical investigation of university student perceptions in Pakistan. *Higher Education Research & Development*, *36*(4), 730-746. https://doi.org/10.1080/07294360.2016.1236782

Jääskä, E., & Aaltonen, K. (2022). Teachers' experiences of using game-based learning methods in project management higher education. *Project Leadership and Society*, *3*, 100041. https://doi.org/10.1016/j.plas.2022.100041

Jean Justice, L., & Ritzhaupt, A. D. (2015). Identifying the barriers to games and simulations in education: Creating a valid and reliable survey. *Journal of Educational Technology Systems*, *44*(1), 86-125. https://doi.org/10.1177/0047239515588161

Jong, M. S. Y., & Shang, J. (2015). Impeding phenomena emerging from students' constructivist online game-based learning process: Implications for the importance of teacher facilitation. *Journal of Educational Technology & Society*, *18*(2), 262-283.

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society*, *21*(3), 48-59.

Kesmodel, U. S. (2018). Cross-sectional studies–what are they good for?. *Acta obstetricia et gynecologica Scandinavica*, *97*(4), 388-393. https://doi.org/10.1111/aogs.13331

Kim, J. B., & Watson, E. (2017). *Exploring practical potentials of business simulation games.* Proceedings of the 50th Hawaii International Conference on System Sciences.

Kock, N. (2015). Common method bias in PLS-SEM: A full collinearity assessment approach. *International Journal of e-Collaboration (ijec)*, *11*(4), 1-10.

Koutska, I. (2023). Educational technology 'introduced' by the COVID-19 pandemic. *Innoeduca. International Journal of Technology and Educational Innovation*, *9*(2), 115–133. https://doi.org/10.24310/innoeduca.2023.v9i2.15481

Krath, J., Schürmann, L., & Von Korflesch, H. F. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Computers in Human Behavior*, *125*, 106963. https://doi.org/10.1016/j.chb.2021.106963

Lester, D., Skulmoski, G. J., Fisher, D. P., Mehrotra, V., Lim, I., Lang, A., & Keogh, J. W. (2023). Drivers and barriers to the utilisation of gamification and game-based learning in universities: A systematic review of educators' perspectives. *British Journal of Educational Technology, 54*, 1748-1770. https://doi.org/10.1111/bjet.13311

Liu, Y., Zhao, L., & Su, Y. S. (2022). Exploring Factors of Preschool Parents' Behavioral Intention to Use Face Recognition Technology on Campus. *Frontiers in Physics*, *10*, 320. https://doi.org/10.3389/fphy.2022.857751

López, F. R., Arias-Oliva, M., Pelegrín-Borondo, J., & Marín-Vinuesa, L. M. (2021). Serious games in management education: An acceptance analysis. *The International Journal of Management Education*, *19*(3), 100517. https://doi.org/10.1016/j.ijme.2021.100517

Lu, J., Hallinger, P., & Showanasai, P. (2014). Simulation-based learning in management education: A longitudinal quasi-experimental evaluation of instructional effectiveness. *Journal of Management Development*, *33*(3), 218-244. https://doi.org/10.1108/JMD-11-2011-0115

Mailizar, M., Burg, D., & Maulina, S. (2021). Examining university students' behavioural intention to use e-learning during the COVID-19 pandemic: An extended TAM model. *Education*

and Information Technologies, *26*(6), 7057-7077. https://doi.org/10.1007/s10639-021-10557-5

Malatji, W. R., Eck, R. V., & Zuva, T. (2020). Understanding the usage, modifications, limitations and criticisms of technology acceptance model (TAM). *Advances in Science, Technology and Engineering Systems Journal*, *5*(6), 113-117. http://dx.doi.org/10.25046/aj050612

McGarr, O. (2020). The use of virtual simulations in teacher education to develop pre-service teachers' behaviour and classroom management skills: implications for reflective practice. *Journal of Education for Teaching*, *47*(2), 274-286. https://doi.org/10.1080/02607476.2020.1733398

Moorthy, K., Chun T'ing, L., Ming, K. S., Ping, C. C., Ping, L. Y., Joe, L. Q., & Jie, W. Y. (2019). Behavioral intention to adopt digital library by the undergraduates. *International Information & Library Review, 51*(2), 128-14. https://doi.org/10.1080/10572317.2018.1463049

National Institutional Ranking Framework. (2021). *National Institute Ranking Framework*. https://www.nirfindia.org/Rankings/2021/ManagementRanking.html

Pando-Garcia, J., Periañez-Cañadillas, I., & Charterina, J. (2016). Business simulation games with and without supervision: An analysis based on the TAM model. *Journal of Business Research*, *69*(5), 1731-1736. https://doi.org/10.1016/j.jbusres.2015.10.046

Pasin, F., & Giroux, H. (2011). The impact of a simulation game on operations management education. *Computers & Education*, *57*(1), 1240-1254. https://doi.org/10.1016/j.compedu.2010.12.006

Pongpanich, C., Krabuanrat, T., & Tan, K. H. (2009). Educator insight on simulations and games: A comparative study between business schools in Thailand and the UK. *On the Horizon, 17*(4), 323-329. https://doi.org/10.1108/10748120910998380

Rafique, H., Ul Islam, Z., & Shamim, A. (2023). Acceptance of e-learning technology by government school teachers: Application of extended technology acceptance model. *Interactive Learning Environments*, 1-19. https://doi.org/10.1080/10494820.2022.2164783

Rahman, M. M., Lesch, M. F., Horrey, W. J., & Strawderman, L. (2017). Assessing the utility of TAM, TPB, and UTAUT for advanced driver assistance systems. *Accident Analysis & Prevention*, *108*, 361-373. https://doi.org/10.1016/j.aap.2017.09.011

Rajan, C. A., & Baral, R. (2015). Adoption of ERP system: An empirical study of factors influencing the usage of ERP and its impact on end user. *IIMB Management Review*, *27*(2), 105-117. https://doi.org/10.1016/j.iimb.2015.04.008

Roungas, B., Bekius, F., Verbraeck, A., & Meijer, S. (2021). Improving the decision-making qualities of gaming simulations. *Journal of Simulation*, *15*(3), 177-190. https://doi.org/10.1080/17477778.2020.1726218

Sagnier, C., Loup-Escande, E., Lourdeaux, D., Thouvenin, I., & Valléry, G. (2020). User acceptance of virtual reality: an extended technology acceptance model. *International Journal of Human–Computer Interaction*, *36*(11), 993-1007. https://doi.org/10.1080/10447318.2019.1708612

Sánchez-Mena, A., & Martí-Parreño, J. (2017). Drivers and barriers to adopting gamification: Teachers' perspectives. *Electronic Journal of e-Learning*, *15*(5), pp434-443.

Saroia, A. I., & Gao, S. (2019). Investigating university students' intention to use mobile learning management systems in Sweden. *Innovations in Education and Teaching International*, *56*(5), 569-580. https://doi.org/10.1080/14703297.2018.1557068

Sarstedt, M., & Cheah, J. H. (2019). Partial least squares structural equation modeling using SmartPLS: a software review. *J Market Anal* **7**, 196-202 (2019). https://doi.org/10.1057/s41270-019-00058-3

Sayginer, C. (2023). Acceptance and use of cloud-based virtual platforms by higher education vocational school students: application of the UTAUT model with a PLS-SEM approach. *Innoeduca. International Journal of Technology and Educational Innovation*, *9*(2), 24-38. https://doi.org/10.24310/innoeduca.2023.v9i2.15647

Sharma, L., & Srivastava, M. (2020). Teachers' motivation to adopt technology in higher education. *Journal of Applied Research in Higher Education*, *12*(4), 673-692. https://doi.org/10.1108/JARHE-07-2018-0156

Sharma, S., & Saini, J. R. (2022). On the role of teachers' acceptance, continuance intention and self-efficacy in the use of digital technologies in teaching practices. *Journal of Further and*

Higher Education, *46*(6), 721-736. https://doi.org/10.1080/0309877X.2021.1998395

Siala, H., Kutsch, E., & Jagger, S. (2020). Cultural influences moderating learners' adoption of serious 3D games for managerial learning. *Information Technology & People*, *33*(2), 424-455. https://doi.org/10.1108/ITP-08-2018-0385

Sierra, J. (2020). The potential of simulations for developing multiple learning outcomes: The student perspective. *The International Journal of Management Education*, *18*(1), 100361. https://doi.org/10.1016/j.ijme.2019.100361

Staples, D. S., & Seddon, P. (2004). Testing the technology-to-performance chain model. *Journal of Organizational and End User Computing (JOEUC)*, *16*(4), 17-36. https://doi.org/10.4018/joeuc.2004100102

Venkatesh, V., & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: Development and test. *Decision sciences, 27*(3), 451-481.

Vlachopoulos, D., & Makri, A. (2017). The effect of games and simulations on higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education*, *14*(1), 1-33. https://doi.org/10.1186/s41239-017-0062-1

Voorhees, C. M., Brady, M. K., Calantone, R., & Ramirez, E. (2016). Discriminant validity testing in marketing: an analysis, causes for concern, and proposed remedies. *Journal of the academy of marketing science, 44*, 119-134. https://psycnet.apa.org/doi/10.1007/s11747-015-0455-4

Vos, L., & Brennan, R. (2010). Marketing simulation games: student and lecturer perspectives. *Marketing Intelligence & Planning*, *28*(7), 882-897. https://doi.org/10.1108/02634501011086472

Watson, W., & Yang, S. (2016). Games in schools: Teachers' perceptions of barriers to game-based learning. *Journal of Interactive Learning Research*, *27*(2), 153-170.

Wijaya, T. T., Cao, Y., Bernard, M., Rahmadi, I. F., Lavicza, Z., & Surjono, H. D. (2022a). Factors influencing microgame adoption among secondary school mathematics teachers supported by structural equation modelling-based research. *Frontiers in Psychology*, *13*, 952549. https://doi.org/10.3389/fpsyg.2022.952549

Wijaya, T. T., Cao, Y., Weinhandl, R., Yusron, E., & Lavicza, Z. (2022b). Applying the UTAUT model to understand factors affecting micro-lecture usage by mathematics teachers in China. *Mathematics*, *10*(7), 1008. https://doi.org/10.3390/math10071008

Wu, B., & Chen, X. (2017). Continuance intention to use MOOCs: Integrating the technology acceptance model (TAM) and task technology fit (TTF) model. *Computers in human behavior*, *67*, 221-232. https://doi.org/10.1016/j.chb.2016.10.028

Zhi, R., Wang, Y., & Wang, Y. (2023). The role of emotional intelligence and self-efficacy in EFL teachers' technology adoption. *The Asia-Pacific Education Researcher, 33,* 845-856. https://doi.org/10.1007/s40299-023-00782-6

Zulfiqar, S., Al-reshidi, H. A., Al Moteri, M. A., Feroz, H. M. B., Yahya, N., & Al-Rahmi, W. M. (2021). Understanding and predicting students' entrepreneurial intention through business simulation games: A perspective of COVID-19. *Sustainability*, *13*(4), 1838. https://doi.org/10.3390/su13041838

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Impact of Digital Game-Based Learning on STEM education in Primary Schools: A meta-analysis of learning approaches

Impacto del Aprendizaje Basado en Juegos Digitales en la educación STEM en las escuelas primarias: Un meta-análisis de enfoques de aprendizaje

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ABSTRACT

Enhancing learning outcomes in Science, Technology, Engineering, and Mathematics (STEM) subjects for primary school students remains a challenge. This meta-analysis, guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA), explores Digital Game-Based Learning (DGBL) interventions as a potential solution. Eighteen empirical studies published from 2010 to 2020 were analyzed to identify effective DGBL approaches. Key factors examined include subject disciplines, control treatment, game type, platforms, and intervention duration. Findings reveal significant positive effects of DGBL interventions on learning outcomes, particularly in mathematics, language, and science. The study underscores the importance of optimizing gameplay design and platform choices for DGBL effectiveness and highlights the potential benefits of incorporating DGBL into primary STEM education. Future research should further investigate contributing factors like game genres, technologies, implementation strategies, and specific game components to promote optimal learning processes in diverse educational settings.

KEYWORDS Digital Game-Based Learning; gamification; learning achievement; meta-analysis; primary education; STEM education.

RESUMEN

Mejorar los resultados de aprendizaje en las materias de Ciencias, Tecnología, Ingeniería y Matemáticas (STEM) para los estudiantes de primaria sigue siendo un desafío. Esta meta-análisis, guiada por las Directrices de Elementos Preferentes para las Revisiones Sistemáticas y Meta-Análisis (PRISMA), explora las intervenciones de Aprendizaje Basado en Juegos Digitales

(ABJD) como una posible solución. Se analizaron dieciocho estudios empíricos publicados entre 2010 y 2020 para identificar enfoques efectivos de ABJD. Se examinaron factores clave, como las disciplinas de las materias, el tratamiento de control, el tipo de juego, las plataformas y la duración de la intervención. Los hallazgos revelan efectos positivos significativos de las intervenciones de ABJD en los resultados de aprendizaje, particularmente en matemáticas, lenguaje y ciencias. El estudio subraya la importancia de optimizar el diseño del juego y las opciones de plataforma para la efectividad del ABJD y destaca los posibles beneficios de incorporar el ABJD en la educación STEM de primaria. Las investigaciones futuras deberían investigar más a fondo los factores contribuyentes, como géneros de juegos, tecnologías, estrategias de implementación y componentes específicos del juego para promover procesos de aprendizaje óptimos en diversos entornos educativos.

PALABRAS CLAVE Aprendizaje Basado en Juegos Digitales; gamificación; rendimiento de aprendizaje; meta-análisis; educación primaria; educación STEM.

1. INTRODUCTION

1.1. The Role of DGBL in STEM Education

In the digital age, the integration of technology in education has become more widespread (Bai et al., 2020). STEM education is crucial for equipping students with essential skills for the future workplace (Arztmann et al., 2023). DGBL offers an interactive and engaging way to explore STEM concepts (Gui et al., 2023; Onyekwere & Hoque, 2023), addressing the growing demand for skilled professionals in this sector (Borenstein et al., 2021; Gao et al., 2020; Li et al., 2019). Developing STEM education is vital for unlocking students' career prospects (Oguguo et al., 2023; Wang et al., 2022).

Although the interdisciplinary nature of STEM subjects poses challenges to their comprehension (Corredor et al., 2014; Homer et al., 2020; Sedig, 2008; Yu et al., 2024), DGBL helps mitigate these issues by blending interactive elements with engaging gameplay (Connolly et al., 2012; Guan et al., 2024; Squire, 2006). Various game types, including simulation, role-playing, strategy, and puzzle games, cater to diverse learning preferences and styles (Kiili, 2005; Wouters et al., 2013).

DGBL serve as powerful tools that promote cognitive, social, and emotional growth (Guan et al., 2024; Habgood & Ainsworth, 2011; Papastergiou, 2009) by merging fun and learning to motivate learners (Garris et al., 2002; Gee, 2003; Guan et al., 2024). Their effectiveness in addressing challenges associated with STEM learning is evident as they enable understanding of complex concepts and develop problem-solving skills (Plass et al., 2015; Yu et al., 2024; Chu & Chang, 2014). DGBL encourages students to envision real-life problems, fostering cognitive preparedness and promoting intellectual engagement (Hwang et al., 2016; Prakasha et al., 2024). Endorsed by the National Science Foundation (Borgman et al., 2008; Wang et al., 2022), DGBLs are recognized as an innovative approach for learning in various STEM fields.

1.2. Evaluating the Impact of DGBL on STEM Education in Primary Schools

There is an ongoing debate regarding the definition and effectiveness of DGBL in primary education, particularly concerning their impact on STEM learning outcomes. While some scholars view DGBL as a type of play that generates unconscious learning (Shaffer, 2006; Haidar, 2024), others argue that it involves

integrating gaming elements, such as points, rewards, or competition, into the teaching process (Al-Azawi et al., 2016; Chiappe et al., 2020). This study considers the latter perspective, recognizing gamification as one of the game genres (Chang & Hwang, 2019).

Studies on DGBL have yielded mixed results, with some indicating positive effects on satisfaction, attitudes (Sung & Hwang, 2013), knowledge tests (Erhel & Jamet, 2013), and skills (Qian & Clark, 2016). However, other studies question their effectiveness in theoretical framing (Wu et al., 2012), learning strategy integration (Charsky & Ressle, 2011), and learning objective setting (Sung & Hwang, 2013). Researchers emphasize that appropriate and theoretically sound learning mechanisms are essential for the effectiveness of DGBL in primary STEM education (Chang & Hwang, 2019; Kickmeier-Rust et al., 2008). To confidently incorporate DGBL into their instruction, educators require evidence-based strategies and exemplary cases. By examining these versatile and advantageous methods, teachers can harness the potential of DGBL to enhance STEM learning outcomes and contribute to the ongoing discourse on their effectiveness in primary education.

1.3. The Need for Assessing DGBL in Primary STEM Education

Despite extensive research on the effectiveness of DGBL technology in STEM education at various levels, there is a scarcity of literature specifically examining the impact of DGBL on promoting STEM learning outcomes in primary education (Huang et al., 2019). Existing studies have produced inconsistent results, with some suggesting negative effects on children's concentration and learning rate in STEM subjects (Videnovik et al., 2023), while others indicate positive influences on children's learning pace (Hung et al., 2014).

Although some studies propose that DGBL can enhance mathematical knowledge, reduce anxiety, and boost motivation among children (Hayati & Behnamnia, 2023; Hung et al., 2014), it is essential to acknowledge the lack of substantial evidence regarding their impact on students' academic progress (Arztmann et al., 2023; Giannakos, 2013; Khan et al., 2017). The findings on the influence of DGBL on early learners' STEM learning outcomes remain inconclusive. Consequently, educators face challenges in deciding whether to integrate DGBL into the preschool curriculum.

In this study, the authors focus on assessing the impact of DGBL on primary school students' learning outcomes in STEM subjects. The learning outcomes considered in the research include content knowledge, problem-solving skills, critical thinking, and motivation to learn. By examining the influence of DGBL on these outcomes, the authors aim to contribute to the ongoing discourse on the potential benefits and challenges of incorporating DGBL in primary STEM education. Assessing the effects of DGBL on the acquisition and dissemination of STEM knowledge in primary schools is crucial to provide guidance for educators seeking to optimize learning outcomes. A comprehensive understanding of the impact of DGBL on young learners will contribute to informed decision-making and the development of effective instructional strategies in primary STEM education.

1.4. Comparison between Previous DGBL Reviews and the Current Study

Previous research on the effectiveness of DGBL in STEM education has yielded mixed findings and focused primarily on specific aspects of game-based learning or individual games (Arztmann et al., 2023; Giannakos,

2013; Khan et al., 2017). These studies have offered valuable insights into the potential benefits and challenges associated with DGBL use. However, there remains a need for a comprehensive review that evaluates the broader impact of DGBL on primary school students' academic achievement in STEM education.

The present study aims to address this gap by providing an extensive meta-analysis of 18 academic studies, examining various moderator variables and their potential influence on learning outcomes. The study's focus extends beyond specific games or learning outcomes, offering a more holistic view of DGBL's impact in STEM education.

In comparison to previous reviews, this study considers a wider range of factors, including subject disciplines, control treatment, game type, platforms, and intervention duration, to provide a more comprehensive understanding of the complex interplay between these elements and their contributions to the overall impact of DGBL (Chang & Hwang, 2019; Hung et al., 2014; Qian & Clark, 2016). By expanding the scope of investigation, the current study seeks to offer educators and policymakers a more nuanced understanding of the potential benefits, challenges, and optimal conditions for the successful integration of DGBL in primary STEM education (Behnamnia et al., 2023; Romero & Barma, 2015; Zheng et al., 2024).

2. LITERATURE REVIEW

This section presents a comprehensive analysis of the existing literature on the impact of DGBL on STEM education for primary school students. The synthesis of findings from various studies endeavors to identify patterns, gaps, and trends in the field. This serves to contextualize the current study, which provides a comprehensive analysis of all subject fields in STEM, addressing gaps in existing research and contributing to a more holistic understanding of the role digital educational games play in shaping learning outcomes.

Several studies have investigated the potential benefits of DGBL for enhancing learning outcomes in STEM subjects. Tokac et al. (2019) explored the effects of game-based learning on primary school students' mathematics achievement and found positive influences on learning pace. Similarly, Gao et al. (2020) conducted a meta-analysis and concluded that educational computer games could improve students' learning performance in science and mathematics (Gao et al., 2020).

Research on DGBL has also considered their impact on students' motivation and engagement. For instance, Wu et al. (2012) reappraised game-based learning based on educational theory, emphasizing its potential for fostering learners' motivation and learning outcomes (Wu et al., 2012). Additionally, Qian & Clark (2016) examined the relationship between game-based learning and the development of 21st-century skills, highlighting the positive effects of digital games on students' collaboration, communication, and problem-solving abilities (Qian & Clark, 2016).

Despite these promising findings, some studies have reported mixed results or raised concerns about the effectiveness of DGBL in promoting academic achievement. Niemeyer (2006) suggested negative effects on children's concentration and learning rate in STEM subjects (Neimeyer, 2006), while others indicated that the impact of digital games on students' academic progress remains inconclusive (Arztmann et al., 2023; Giannakos, 2013; Khan et al., 2017).

Furthermore, several studies have focused on the importance of considering various game elements and contextual factors when evaluating the effectiveness of DGBL. For example, Chang & Hwang (2019) examined the effects of different game genres on learning performance (Chang & Hwang, 2019), while Gui et al. (2023) and Solanes et al. (2023) explored the potential of metaverse ecosystems and augmented reality in STEM education (Gui et al., 2023; Solanes et al., 2023).

In conclusion, the literature review demonstrates the complexity and heterogeneity of findings on the impact of DGBL on primary school students' STEM learning outcomes. While some studies suggest positive influences, others report mixed results or raise concerns about their effectiveness. The present study aims to address these inconsistencies by conducting a comprehensive meta-analysis of 18 academic studies, examining various moderator variables, and offering a more holistic view of the role of DGBL in primary STEM education.

3. META-ANALYSIS PURPOSE

This study aims to address the limitations and discrepancies found in previous research on Digital Game-Based Learning (DGBL) in primary STEM education. The research focuses on assessing the efficacy of utilizing DGBL in enhancing learning outcomes across STEM subjects. By examining key variables, such as subject disciplines, control treatment, game type, platforms, and intervention duration, the study aims to identify essential principles of effective DGBL design that contribute to learning progress. The following research questions guide this investigation:

1. Is DGBL more effective in improving learning outcomes compared to traditional teaching methods in primary STEM education?
2. Do students' learning outcomes differ based on the STEM subject discipline (Science or Mathematics) when using DGBL?
3. How does gameplay design (game type or game platform) impact learning outcomes in primary STEM education when employing DGBL?
4. What is the relationship between intervention duration and students' academic achievement in DGBL interventions?
5. Do control treatments (traditional teaching methods vs. multimedia or non-game-based interventions) influence the effectiveness of DGBL interventions in primary STEM education?

By addressing these research questions, this study intends to contribute to the existing body of knowledge on the use of DGBL in primary STEM education. It will help identify the most effective approaches and design principles for implementing DGBL in the classroom, thereby improving learning outcomes and informing educational policy and practice.

4. METHOD

Meta-analysis is a widely employed methodology for conducting quantitative and exhaustive analyses of prior research outcomes on a given topic (Glass et al., 1981). This statistical analysis approach enables

systematic studies to address research questions more accurately by adhering to stringent screening criteria (Noble Jr, 2006). As a result, the meta-analysis method facilitates a more reliable examination of independent studies within a systematic review, ensuring greater precision and validity of research results. By reconciling discrepancies arising from conflicting experimental experiences, meta-analysis generates more meaningful and robust outcomes (Paré et al., 2015). Consequently, this study adopts the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) method to maintain rigor and transparency in the research process (Moher et al., 2010; Moher et al., 2015).

4.1. Sources and strategy of data collection

In order to gather relevant information for this study, a thorough search was conducted across various online sources, such as journal collections and websites like Web of Science, ERIC, JSTOR, ESCBO, Science Direct, IEEE Xplore, Springer, Scopus, and Wiley. To further expand the search scope, the Google Scholar search engine was also utilized to cover more studies. The eligibility criteria for selecting studies included publications from 2010 to 2020, written in English.

4.1.1 Rationale for Journal Selection and Time Range

The selected journal was chosen for its relevance to the research topic, as it caters to an audience of researchers and practitioners in the fields of education and technology. The time range was chosen to capture recent advancements in digital game-based learning while ensuring the inclusion of studies that have informed current practices.

To facilitate an organized search process, three sets of keywords were defined, combined using Boolean operators (AND, OR). The first set of keywords aimed to establish the scope of DGBL, incorporating terms like “game,” “educational game,” “digital game,” and phrases such as “computer games,” “gamification,” “video games,” “simulation games,” “game-based learning,” “serious digital games,” and “teaching with games.”

The second set of keywords targeted STEM-related concepts, including “learning,” “education,” “science,” “technology,” “engineering,” “mathematics,” and “teaching.”

Finally, the third set of keywords focused on primary school education levels and was combined with the first and second sets of keywords. This set comprised terms such as “primary education,” “primary level,” and “primary school teaching.”

The keyword search was executed across various fields, including article titles, abstracts, and full-text content, to ensure a comprehensive and thorough coverage of relevant studies. This multi-faceted approach allowed for the identification of pertinent research articles that explored the impact of DGBL on teaching and learning outcomes in STEM subjects within the primary school setting. By examining and synthesizing these studies, a deeper understanding of the potential benefits and challenges of incorporating DGBL into the curriculum can be achieved, ultimately informing educators’ decisions on effective teaching strategies.

4.2. Literature Search and Eligibility Criteria

The literature search and eligibility criteria for this study concentrated on evaluating the effectiveness of DGBL interventions in primary STEM education in contrast to traditional teaching methods. Comparing these approaches was crucial for comprehending the impact of DGBL within the larger educational landscape. To facilitate this comparison, the search strategy and selection criteria intentionally incorporated conventional teaching methods as a reference point in the meta-analysis. The search strategy incorporated the following key elements:

- *Utilizing search terms related to traditional teaching approaches:* Keywords and phrases such as "conventional teaching," "traditional instruction," "non-digital learning," and "traditional teaching methods" were included to identify studies comparing DGBL interventions with conventional teaching practices.
- *Developing selection criteria for comparative studies:* To be considered for the meta-analysis, studies were required to compare the effectiveness of DGBL interventions with traditional teaching approaches. This entailed selecting studies featuring both an intervention group employing DGBL and a control group utilizing conventional methods.

By implementing a thorough search strategy and establishing clear selection criteria, the meta-analysis effectively captured relevant studies comparing DGBL interventions with traditional teaching approaches in primary STEM education. This approach enabled the analysis of DGBL's impact on learning outcomes and their potential benefits over conventional methods.

4.3. Including and excluding criteria

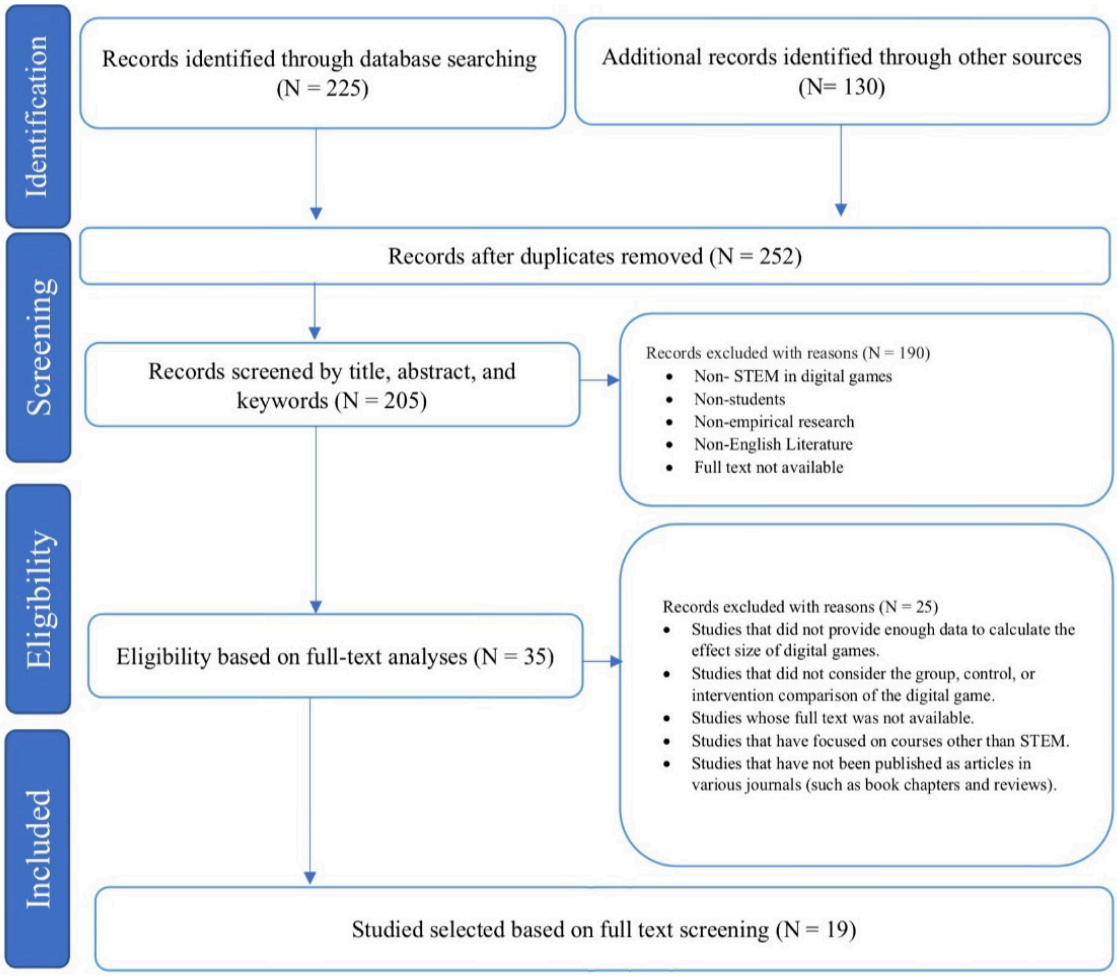
The entry and exit criteria are mentioned in Table 1 in order to find the questions of this research. Following the considering criteria, the research literature that satisfied the meta-analysis requirements of this study was included, while those that did not were omitted (see Table 1).

TABLE 1. Inclusion and Exclusion criteria in the meta-analysis used in this research

INCLUSION CRITERIA IN THE META-ANALYSIS USED IN THIS RESEARCH (IC)	
IC 1	Studies focusing on primary school level education.
IC 2	Studies written in English.
IC 3	Studies examining the impact of DGBL through group intervention and control/nonintervention group comparisons.
IC 4	Studies providing sufficient data to calculate the impact size of DGBL.
IC 5	Studies concentrating on STEM courses.
EXCLUSION CRITERIA IN THE META-ANALYSIS USED IN THIS RESEARCH (EC)	
EC 1	Studies lacking adequate data for calculating the effect size of DGBL.
EC 2	Studies without group comparisons, control groups, or digital game interventions.
EC 3	Studies with unavailable full-text versions.
EC 4	Studies focusing on non-STEM courses.
EC 5	Non-peer-reviewed studies or those published outside of academic journals (e.g., book chapters and reviews).

The data collection process in Figure 1 shows how the search, screening, and selection of qualified articles were done in this article. In the next step, 35 articles were examined for further review, and finally, 18 articles met the criteria for entering this meta-analysis (see Fig.1).

FIGURE 1. PRISMA flowchart for data collection



4.4. Meta-Analysis Approach

This study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method as the primary approach for conducting the meta-analysis. PRISMA is a widely recognized and accepted framework for performing and reporting systematic reviews and meta-analyses, emphasizing transparency, completeness, and rigor throughout the research process (Moher et al., 2010; Moher et al., 2015).

The PRISMA method was chosen for its systematic and comprehensive nature, making it particularly suitable for the research objectives of evaluating the effectiveness of DGBL interventions in primary STEM education. The approach enables a methodical and unbiased identification, selection, and evaluation of relevant studies, ensuring the reliability and generalizability of the findings.

The PRISMA method comprises several essential steps:

1. Define the research question and establish eligibility criteria for study inclusion and exclusion.
2. Conduct a comprehensive literature search using multiple databases and online sources.
3. Screen and select studies based on the predetermined eligibility criteria.
4. Extract relevant data from the selected studies and assess their quality.
5. Analyze the extracted data using appropriate statistical methods and techniques.
6. Interpret the results and draw conclusions based on the synthesized evidence.

By systematically following these steps, the PRISMA method allows for the assessment of the impact of DGBL interventions in primary STEM education, identification of potential gaps in the existing literature, and provision of insights into areas that require further investigation. In conclusion, the adoption of the PRISMA method ensures a thorough, transparent, and comprehensive approach to evaluating the effectiveness of DGBL interventions in primary STEM education.

4.5. Indicators of Moderation

Moderation indicators refer to specific characteristics in each study and their relationship with study results. These indicators cause variance in the effect size due to the variation in the outcomes of the studies. Common moderation indicators used in this study included subject disciplines, control treatment, game type, platforms, and intervention duration. These variables have also been employed in previous studies to determine the difference in effect size heterogeneity (Chen et al., 2018; Thompson & von Gillern, 2020; Zeng et al., 2020). To address the research questions, the following moderation indicators were coded (see Table 2).

TABLE 2. Moderator data in studies

Paper id	Sample size	Subject	Control treatment	Game type	Gaming platform	Intervention duration	Authors (year)
P 1	136	Science	Traditional	Tutorial Games	Computer	≥3 months	(Anderson & Barnett , 2011)
P 2	49	Science	Multimedia	Tutorial Games	Mobile	1 week–1 month	(Chen, 2020)
P 3	51	Science	Multimedia	Board Games	Mobile	<1 week	(Chen et al., 2016)
P 4	115	Science	Traditional	Immersive Games	Computer	1 month–3 months	(Chen et al., 2020)
P 5	53	Science	Multimedia	Immersive Games	Computer	<1 week	(Chu & Chang, 2014)
P 6	103	Mathematics	Traditional	Tutorial Games	Mobile	1 month–3 months	(van der Ven et al., 2017)
P 7	232	Science	Traditional	Immersive Games	Computer	1 month–3 months	(Hodges et al., 2020)
P 8	46	Mathematics	Traditional	Tutorial Games	Mobile	<1 week	(Hung et al., 2014)

Paper id	Sample size	Subject	Control treatment	Game type	Gaming platform	Intervention duration	Authors (year)
P 9	50	Science	Multimedia	Board Games	Computer	<1 week	(Hwang et al., 2012)
P 10	60	Science	Multimedia	Immersive Games	Computer	<1 week	(Hwang et al., 2013)
P 11	57	Science	Multimedia	Board Games	Mobile	<1 week	(Hwang et al., 2016)
P 12	61	Mathematics	Traditional	Immersive Games	Computer	1 month–3 months	(Ke, 2019)
P 13	132	Mathematics	Multimedia	Immersive Games	Computer	<1 week	(Kim & Ke, 2017)
P 14	62	Mathematics	Multimedia	Board Games	Computer	<1 week	(Lin et al., 2013)
P 15	185	Science	Multimedia	Immersive Games	Computer	<1 week	(Stege et al., 2012)
P 16	102	Science	Multimedia/ Traditional	Tutorial Games	Mobile	Not specified	(Su & Cheng, 2013)
P 17	36	Science	Traditional	Tutorial Games	Mobile	1 month–3 months	(Yallihep & Kutlu, 2020)
P 18	65	Mathematics	Traditional	Tutorial Games	Mobile	<1 week	(Zhang et al., 2020)

- Discipline of subject: Research investigating one of the STEM subjects was considered in line with the definition of the subject (Wahono et al., 2020). Based on the classification adopted in this study, the coding was categorized according to STEM disciplines, including science, mathematics, and technology or engineering. The analysis of the impact of DGBL on learning rate was conducted based on this coding.
- Control treatment: This study focused on whether DGBL are effective in promoting learning. In this context, the analysis based on control treatment was employed, which determines the extent of learning promotion through DGBL in comparison to non-digital game teaching methods. Control treatment has been regarded as a moderation index in past studies (Garzón & Acevedo, 2019; Merchant et al., 2014; Wouters et al., 2013). Two categories of coding, "traditional" and "multimedia," were utilized in the meta-analysis to analyze the moderation index in control treatment. Traditional education in classroom settings included the presence of teachers, textbooks with assignments, and real-world experimental experiments, while DGBL involving animation or lessons played on computers or other digital devices were coded as "multimedia."
- Game type: Games are typically divided into two categories: role-playing games (Li & Tsai, 2013) and non-role-playing games. DGBL encompasses eight categories: immersive games, educational games, training games, simulation games, adventure games, music games, board games, and alternative reality games (Hung et al., 2018). The framework for analyzing DGBL used in the studies is based on Hong et al.'s (2009) classification framework. The games identified in the reviewed studies consist of immersive games, tutorial games, and board games (Hong et al., 2009).

- Platforms: Common platforms include computers, mobile phones, touch tablets, gaming consoles (e.g., PlayStation or Xbox), and unidentified gadgets. Hardware types can influence how players learn in the game (Thompson & von Gillern, 2020). The most popular gaming platforms were selected based on reviews in the articles, which included PCs, mobile devices, and touch tablets.
- Intervention duration: The duration of an educational intervention, such as the use of DGBL, can influence the extent to which learning outcomes are achieved.
  - Shorter interventions, lasting less than one week, may lead to more immediate and targeted outcomes, such as the acquisition of specific content knowledge or the development of a particular skill. These interventions can be effective in reinforcing key concepts and engaging students in focused learning experiences.
  - Longer interventions, lasting more than three months, may provide more opportunities for learners to develop a deeper understanding of complex concepts and demonstrate higher-order thinking skills. These interventions can support the development of problem-solving strategies, critical thinking, and sustained motivation to learn. Intervention duration was coded based on the durations specified in the selected studies, following previous research (Bai et al., 2020; Chen et al., 2018). This coding comprised (a) <1 week, (b) 1 week to 1 month, (c) >1 month to 3 months, (d) >3 months, and (e) not specified.

4.6. Analysis of collected data

The study's focal point was the influence of DGBL on the acquisition of knowledge among primary school students. The study utilized Comprehensive Meta-analysis 3.0 software to compute impact size and ascertain moderating variables. The study's objective was to assess the efficacy of DGBL in contrast to non-digital educational games instruction, concentrating on determining the extent of the impact. The standardized mean difference was utilized to quantify the impact size. To evaluate study homogeneity, the Q statistic and I^2 value were utilized. The study's results indicated substantial heterogeneity, as suggested by a statistically significant Q statistic, which refuted the null hypothesis of homogeneity (Lipsey & Wilson, 2001). Borenstein et al. (2010) discovered that the random-effects model had a superior fit and suggested examining moderator variables (Borenstein et al., 2010). Hedges' (1982) method was utilized to determine ES(d) (Hodges et al., 2020).

$$ES = \frac{ME - MC}{\sqrt{\frac{(NE - 1)S_E^2 + (NC - 1)S_C^2}{(NE + NC - 2)}}}$$

The equation uses different variables to represent different aspects. ES represents the efficiency score of a specific entity, *M*E represents the mean efficiency score of all entities in the system, *MC* represents the marginal cost of production, *NE* represents the number of inputs used by the entity, S^2E represents the variance of inefficiencies in input, *NC* represents the number of outputs generated by the entity, and S^2C represents the variance of inefficiencies in output. This equation calculates the efficiency score of a particular entity by considering the mean efficiency of all entities, the marginal cost of production, the number of

inputs and outputs, and the variances of inefficiencies in input and output. It is a useful tool for analyzing organizational efficiency in specific industries or contexts. In this study, *ME* and *MC* represent the estimated means of the experimental and control groups, respectively. *NE* and *NC* represent the sample sizes of these groups, and *S2E* and *S2C* represent their respective standard deviations.

4.7. Analysis of bias and variability in publications

Meta-analyses can be influenced by various biases, such as publication bias, where only positive outcomes are reported (Borenstein et al., 2010; Egger et al., 1997). To assess potential publication bias, this study employed the fail-safe value approach instead of the funnel plot technique. The fail-safe value method estimates the number of unpublished studies with null results needed to negate the observed effect, providing a quantitative measure of the robustness of meta-analytic findings (Rosenthal, 1979). The Begg and Mazumdar rank correlation test found no significant bias ($Z = 1.457 < 1.96$, $p = 0.145 > 0.05$), suggesting the absence of publication bias (Begg & Mazumdar, 1994). The traditional fail-safe N test was also employed, yielding a fail-safe value of 3001. This indicates that a substantial number of unpublished studies would be required to render the effect sizes insignificant, further supporting the absence of publication bias. Heterogeneity was evaluated using I^2 values. The I^2 test complements the Q-test, with values of 0%–25% indicating low, 25%–75% indicating moderate, and 75%–100% indicating substantial heterogeneity (Higgins et al., 2003). Significant heterogeneity was found ($p < 0.001$), necessitating the use of a random-effects model to account for variations in effect sizes across studies (Wang et al., 2020).

In this study, the fail-safe value was calculated as 83. This result suggests that 83 unpublished studies with null results would be needed to negate the positive outcomes reported in the meta-analysis, indicating a robust observed effect. Table 3 presents individual effect sizes, standard errors, variances, lower and upper limits, z-values, p-values, and overall effect sizes for each of the 18 studies included in the meta-analysis. All studies showed a large effect size, with p-values less than 0.05, except for studies P7 and P14. Despite these two studies having large effect sizes, their results are not statistically significant. Incorporating the fail-safe value in the analysis aimed to provide a transparent evaluation of potential publication bias, highlighting the robustness of the findings and contributing to the growing body of research on DGBL in primary STEM education (See Table 3 for more details).

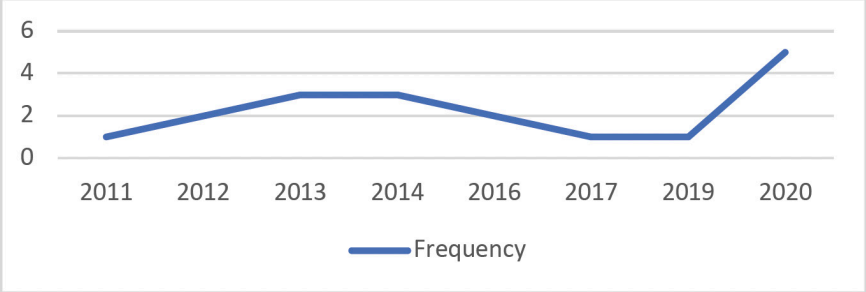
5. RESULTS

The 18 studies (P1-P18) examined DGBL in various primary STEM education contexts, focusing on subjects such as Science (11 studies) and Mathematics (7 studies). Control treatments included traditional teaching methods (9 studies) and multimedia/non-game-based interventions (remaining studies). Tutorial games were most commonly employed (9 studies), followed by immersive games (6 studies) and board games (3 studies). Platforms included computers (11 studies) and mobile devices (7 studies). Intervention durations ranged from short-term (<1 week; 8 studies) to medium-term (1-3 months; 4 studies) and long-term (>3 months; 3 studies). These studies offer insights into DGBL's efficacy in improving learning outcomes and its potential advantages over traditional teaching methods in primary STEM education.

5.1. Distribution of Studies Over Time

The reviewed studies demonstrated a gradual increase in DGBL research for primary STEM education, with a notable peak in 2020. Publication years ranged from 2011 to 2020, with the highest concentrations of studies in 2014 (3 studies) and 2020 (5 studies), indicating a growing interest and research field in this area (see Fig. 2).

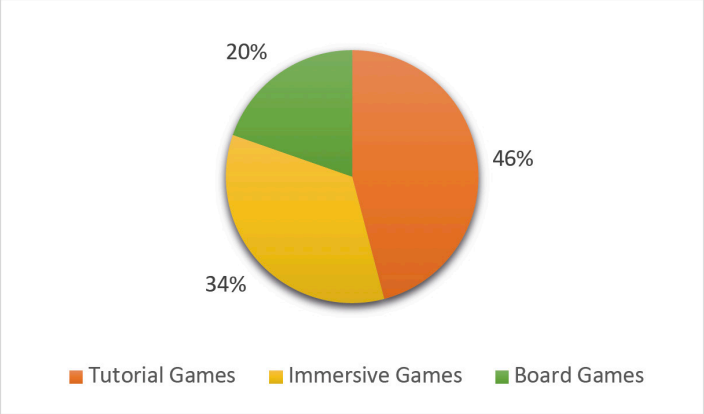
FIGURE 2. Number of published papers per year



5.2. Analysis of Game Types in DGBL Interventions

The studies reviewed predominantly employed tutorial games (44.4%; 8 studies) for DGBL interventions, likely due to their ability to provide guided instruction and enhance problem-solving skills in STEM subjects. Immersive games (33.3%; 6 studies) and board games (22.2%; 4 studies) were also utilized, reflecting diverse approaches to integrating DGBL in primary education (see Fig. 3).

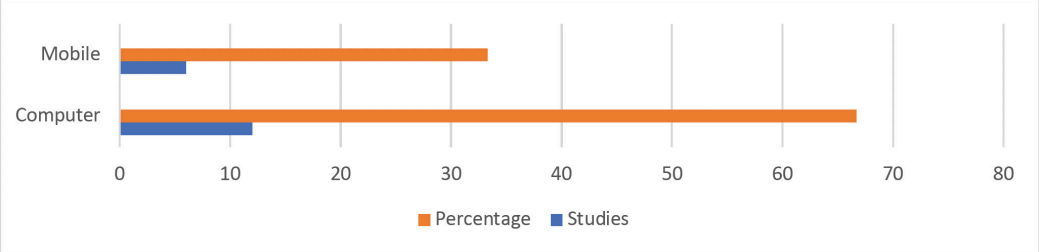
FIGURE 3. Pie Chart: Game Types



5.3. Analysis of Gaming Platforms in DGBL Interventions

The reviewed studies predominantly utilized computers (66.7%; 12 studies) as the gaming platform for DGBL interventions due to their versatility and functionality. However, mobile devices (33.3%; 6 studies) also demonstrated significant presence, reflecting a growing interest in leveraging portable and accessible technology for enhancing STEM learning among primary school students.

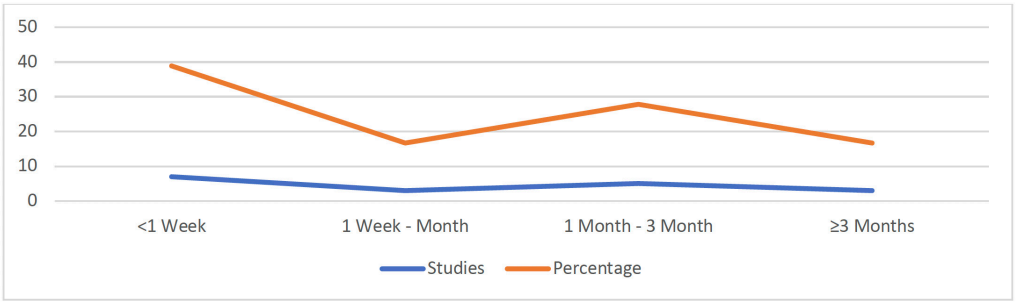
FIGURE 4. Gaming Platforms



5.4. Analysis of Intervention Duration in DGBL Studies

The studies primarily implemented short-term DGBL interventions (38.9%; 7 studies) due to factors like resource limitations and curriculum integration challenges. However, longer interventions (16.7%; 3 studies) were also present, acknowledging potential benefits of sustained DGBL engagement for enhancing primary school students' learning outcomes in STEM subjects. Intervention durations varied from less than one week to over three months (see Fig. 5).

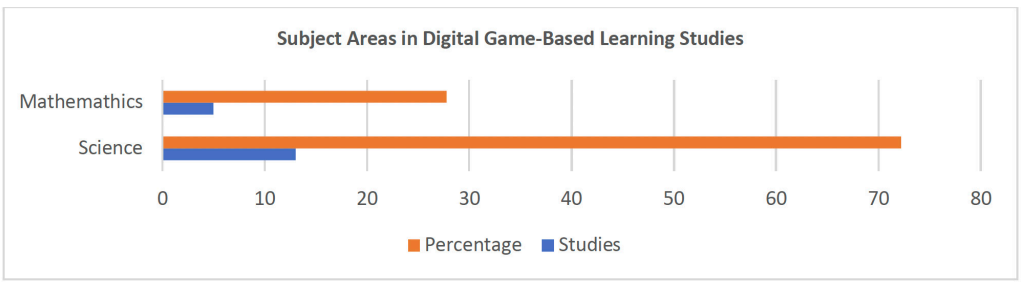
FIGURE 5. Intervention Duration



5.5. Analysis of Subject Areas in DGBL Studies

Most studies focused on using DGBL for Science subjects (72.2%; 13 studies), with fewer focusing on Mathematics (27.8%; 5 studies). This distribution highlights the preference for DGBL in Science education, likely due to its potential for integrating real-world phenomena through engaging game elements. Mathematics-focused interventions reflect DGBL's recognized value in promoting problem-solving skills and conceptual understanding in this key STEM subject (see Fig. 6).

FIGURE 6. Subject Areas in DGBL Studies



5.6. Findings of the study

This section discusses the findings of the study, addressing the following research questions:

5.6.1. The Impact of DGBL on STEM Learning in Primary Education

A meta-analysis of 18 studies (1595 participants) assessed DGBL's overall impact on students' learning outcomes, using Cohen's effect size criteria (Cohen, 2013). The weighted average of standardized differences in means across studies was 0.834 (standard error: 0.123), indicating a large effect size per Cohen's criteria. This suggests a significant positive impact of DGBL on primary school students' learning outcomes in STEM subjects. Table 3 summarizes the overall effect size and highlights DGBL's influence on learning outcomes in Mathematics, Science, and Language, supporting its integration in STEM education for enhancing primary school students' learning outcomes (see Table 3 for details).

TABLE 3. Random-effect model forest plot displaying all included effect sizes in the forest plot

Paper id	Std diff in means	Standard error	Variance	Lower limit	Upper limit	Z-value	P-value	Effect size (cohen's d)	Authors (Year)
P 1	0.891	0.180	0.032	0.539	1.244	4.953	0.000	Large	(Anderson et al., 2011)
P 2	0.454	0.289	0.084	0.113	1.021	1.569	0.117	Medium	(Chen, 2020)
P 3	3.380	0.437	0.191	2.524	4.236	7.740	0.000	Large	(Chen et al., 2016)
P 4	0.554	0.190	0.036	0.182	0.927	2.916	0.004	Medium	(Chen et al., 2020)
P 5	0.854	0.287	0.082	0.291	1.416	2.975	0.003	Large	(Chu et al., 2014)
P 6	0.650	0.202	0.041	0.253	1.046	3.212	0.001	Medium	(van der Ven et al., 2017)
P 7	0.068	0.132	0.017	0.190	0.327	0.518	0.605	Small	(Hodges et al., 2020)
P 8	0.704	0.304	0.092	0.109	1.300	2.317	0.020	Medium	(Hung et al., 2014)
P 9	2.428	0.376	0.141	1.692	3.164	6.464	0.000	Large	(Hwang et al., 2012)
P 10	0.593	0.264	0.070	0.076	1.110	2.247	0.025	Medium	(Hwang et al., 2013)
P 11	0.517	0.270	0.073	0.011	1.046	1.919	0.055	Medium	(Hwang et al., 2016)
P 12	0.988	0.287	0.082	0.425	1.550	3.441	0.001	Large	(Ke, 2019)
P 13	1.161	0.188	0.035	0.792	1.529	6.168	0.000	Large	(Kim et al., 2017)
P 14	0.455	0.257	0.066	0.049	0.960	1.769	0.077	Medium	(Lin et al., 2013)
P 15	0.292	0.148	0.022	0.002	0.582	1.975	0.048	Small	(Stege et al., 2012)
P 16	0.758	0.261	0.068	0.246	1.270	2.902	0.004	Medium	(Su et al., 2013)
P 17	2.025	0.414	0.171	1.214	2.836	4.894	0.000	Large	(Yallihep et al., 2020)
P 18	0.451	0.251	0.063	0.041	0.944	1.796	0.073	Medium	(Zhang et al., 2020)

Note: Effect sizes are categorized as Small (d = 0.2), Medium (d = 0.5), and Large (d = 0.8) according to Cohen's (1988) criteria.

RESEARCH QUESTION 1: Is DGBL more effective in improving learning outcomes compared to traditional teaching methods in primary STEM education?

The meta-analysis of 18 studies, involving 1595 participants, revealed a significant positive impact of DGBL on primary school students' learning outcomes in STEM subjects. The overall large effect size (0.834, SE = 0.123) demonstrates the superiority of DGBL over traditional teaching methods. However, the individual study results varied, with 16 out of 18 studies showing statistically significant positive outcomes, while two studies reported nonsignificant effects. This variability underscores the importance of considering factors like game type, instructional design, and individual student differences when evaluating DGBL's effectiveness in primary STEM education.

5.6.2. The Impact of DGBL on Learning Outcomes Across STEM Subject Disciplines

RESEARCH QUESTION 2: Do students' learning outcomes differ based on the STEM subject discipline (Science or Mathematics) when using DGBL?

Research Question 2 explored the impact of DGBL on learning outcomes across STEM subject disciplines. The meta-analysis revealed significant differences in effect sizes among Mathematics, Science, and Language. Mathematics showed the strongest positive impact on students' learning outcomes (ES = 0.607, $p < 0.001$), followed by Language (ES = 0.740, $p < 0.001$), and Science (ES = 0.478, $p < 0.001$). No significant difference was found between studies in Science and Mathematics, suggesting that DGBL positively impacts both domains. Further details are available in Table 4 (See Table 4 for more details).

5.6.3. Impact of Gameplay Design on Learning Success

RESEARCH QUESTION 3: How does gameplay design (game type or game platform) impact learning outcomes in primary STEM education when employing DGBL?

Research Question 3 explored gameplay design's influence on learning outcomes in primary STEM education, examining game types and platforms. The meta-analysis showed significant effect size differences among game types, with board games having the largest effect size (ES = 0.658, $p < 0.001$). Immersive (ES = 0.483, $p < 0.001$) and tutorial games (ES = 0.646, $p < 0.001$) also demonstrated significant effects. The analysis suggested mobile devices and touch tablets positively impacted learning outcomes more than computers, though mixed findings indicated other factors might play a role (see Table 4).

5.6.4. Impact of Intervention Duration on Academic Attainment

RESEARCH QUESTION 4: What is the relationship between intervention duration and students' academic achievement in DGBL interventions?

Research Question 4 investigated the relationship between intervention duration and academic achievement in DGBL interventions. The results showed a significant impact of intervention duration on academic achievement, with brief interventions lasting less than one week demonstrating the strongest

positive effect on learning outcomes (ES = 0.773, p < 0.001). Longer interventions yielded smaller effect sizes, indicating that shorter interventions might be more effective due to reduced novelty effects. Further information can be found in Table 4 (see Table 4).

5.6.5. Influence of Control Treatments on the Effectiveness of Digital Educational Games in Primary STEM Education

- **RESEARCH QUESTION 5:** Do control treatments (traditional teaching methods vs. multimedia or non-game-based interventions) influence the effectiveness of DGBL interventions in primary STEM education?

Research Question 5 explored the influence of control treatments on the effectiveness of DGBL interventions in primary STEM education. The meta-analysis showed a significant effect of control treatments on learning outcomes (p < 0.05), with DGBL interventions demonstrating greater improvement compared to traditional teaching methods. This suggests that DGBL can be more effective than conventional approaches. However, the difference in learning outcomes between DGBL interventions and multimedia or non-game-based interventions was less significant, emphasizing the importance of considering control treatments when assessing DGBL intervention effectiveness.

TABLE 4. The impact of moderator variables on effect size in the random-effect model≤

Moderator variables		N	Effect Size (ES)	Standard Error (SE)	Variance	95% CI		Q_b
						Lower limit	Upper limit	
Subject	Science	12	0.761	0.219	0.048	0.397	1.171	0.352
	Mathematics	6	0.571	0.233	0.054	0.357	1.248	
Control Treatment	Traditional	8	0.571	0.202	0.040	0.304	0.979	0.387
	Multimedia	10	0.768	0.242	0.059	0.497	1.422	
Game Type	Tutorial Games	7	0.646	0.244	0.059	0.337	1.271	0.388
	Board Games	4	0.658	0.329	0.108	0.987	2.239	
	Immersive Games	7	0.483	0.182	0.033	0.258	0.869	
Gaming Platform	Computer	10	0.618	0.195	0.038	0.347	1.025	0.285
	Mobile	8	0.802	0.283	0.080	0.467	1.552	
Intervention duration	<1 week	10	0.773	0.244	0.059	1.400	3.462	3.852
	1 week–1 month	2	0.381	0.27	0.073	1.209	2.468	
	1 month–3 months	5	0.432	0.193	0.037	0.891	2.142	
	≥3 months	1	0.18	0.18	0.032	1.240	4.950	

N Number of effect size; ES, effect size; SE, Standard Error; Q_b; Q Value of the heterogeneity test between the subgroups; CI, Confidence Interval; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

6. DISCUSSION

6.1. Comparison of DGBL Interventions and Traditional Teaching Methods

The meta-analysis conducted by the authors revealed a significant positive impact of DGBL interventions on primary school students' learning outcomes in STEM subjects compared to traditional teaching methods. This finding suggests that DGBL can provide an engaging and interactive learning environment, resulting in improved academic achievement. However, the authors also found that the difference in effectiveness between DGBL interventions and multimedia or non-game-based interventions was less distinct, indicating that the unique features of DGBL may offer a marginal advantage over other technology-enhanced learning approaches.

Student characteristics and game design features may moderate the relationship between DGBL interventions and learning outcomes. For example, students with different levels of prior knowledge or motivation may benefit differently from DGBL. Additionally, specific game design elements, such as feedback mechanisms or problem-solving tasks, could influence the effectiveness of DGBL in promoting STEM education, as highlighted in the analysis.

The findings reveal that DGBL interventions yield improved learning outcomes compared to traditional teaching methods, a finding supported by other research (Chen, 2020; Tsai & Tsai, 2020). These findings align with the understanding that DGBL approaches can provide an engaging and interactive environment, leading to increased motivation and enhanced academic achievement (Anderson et al., 2011; Khan et al., 2017). However, the difference in effectiveness between DGBL interventions and other technology-enhanced learning methods, such as multimedia or non-game-based interventions, was less distinct. This observation suggests that while DGBL can offer advantages over traditional teaching methods, their unique features may only provide a marginal benefit over other technology-enhanced learning strategies (Tsai & Tsai, 2020).

6.2. Influence of STEM subject disciplines on learning outcomes

The authors observed that learning success varied across subject disciplines in DGBL interventions, with mathematics demonstrating the largest effect sizes, followed by language and science. This finding suggests that some subjects may be more amenable to DGBL, possibly due to differences in content or learning processes.

For instance, mathematics frequently involves problem-solving and skill-building, which can be readily integrated into game mechanics. In contrast, science may necessitate a more complex conceptual understanding that might be more challenging to convey through games.

By examining the unique characteristics of each discipline and tailoring DGBL interventions accordingly, educators can optimize the effectiveness of DGBL in promoting learning success across various subject areas. This approach may contribute to a more comprehensive and targeted use of DGBL in primary STEM education.

This study indicates that the effectiveness of DGBL varies across different STEM subject disciplines, highlighting the importance of considering the specific learning context and objectives when implementing DGBL

strategies (Bai et al., 2020; Tsai & Tsai, 2020). For instance, DGBL may be particularly effective in enhancing problem-solving skills in mathematics or promoting conceptual understanding in science. These findings emphasize the need to tailor DGBL interventions to the specific needs and learning objectives of each STEM subject discipline to maximize their effectiveness in promoting academic achievement (Brinson, 2015).

6.3. Impact of gameplay design on learning success

The findings demonstrated that gameplay design, including game types and platforms, had an impact on learning outcomes in primary STEM education. Notably, board games had the most significant effect on learning success compared to mobile devices, touch tablets, and computers. This result could be attributed to the collaborative and tactile nature of board games, which might enhance student engagement and facilitate peer-to-peer learning.

Educators and game developers should weigh the strengths and weaknesses of various gameplay designs when selecting or designing games for STEM education. While mobile devices and touch tablets offer portability and accessibility, board games may be more effective in promoting social interaction and collaboration among students.

The findings indicate that gameplay design significantly affects learning outcomes, which is consistent with previous research (Bai et al., 2020; Chen, 2020; Tsai & Tsai, 2020). The design elements in DGBL, such as feedback mechanisms, problem-solving tasks, and interactivity, can influence students' motivation, engagement, and learning performance (Jia et al., 2016). These findings emphasize the importance of integrating appropriate gameplay design elements in DGBL to enhance their effectiveness in promoting learning success. By thoughtfully incorporating game design features tailored to the needs and characteristics of learners, educators can optimize the potential benefits of DGBL strategies in STEM education (Brinson, 2015).

6.4. Influence of intervention duration on academic attainment

The meta-analysis conducted by the authors revealed a connection between intervention duration and students' academic achievement, with brief interventions showing the largest effect size. This finding supports previous research suggesting that shorter interventions may lead to better learning outcomes due to decreased novelty effects, as students may lose interest in DGBL over time. Consequently, educators should consider the optimal intervention periods to maximize the benefits of DGBL while maintaining student engagement.

Several factors could potentially moderate this relationship, including student characteristics (e.g., attention span or prior knowledge) and game design features (e.g., complexity or variability of game content).

By examining the interplay between intervention duration, student characteristics, and game design features, educators can make more informed decisions about implementing DGBL interventions in primary STEM education. This approach may contribute to enhanced learning outcomes and sustained student engagement in DGBL environments.

The findings from this study are corroborated by various research endeavors. As postulated by Anderson and Barnett (2011) and Khan et al. (2017), developmental barriers can impede academic success and

induce negative attitudes, potentially leading to students abandoning their courses (Anderson & Barnett, 2011; Khan et al., 2017). These observations confirm findings, highlighting the impact of such barriers on students' learning outcomes. In addition, Bai et al. (2020) and Tsai & Tsai (2020) demonstrated that games, game mechanisms, competitive techniques, and gaming platforms significantly influence students' learning outcomes, further confirming the findings (Bai et al., 2020; Tsai & Tsai, 2020). These studies collectively emphasize the importance of addressing developmental barriers and leveraging effective DGBL strategies to enhance academic success.

6.5. Addressing Bias and Variability in Publications

In this meta-analysis, the authors aimed to provide a comprehensive understanding of the effectiveness of DGBL in primary STEM education. However, they acknowledged potential biases and variability in publications that needed to be addressed to ensure the validity of their findings.

One significant challenge faced was the limited number of studies included in the meta-analysis, which can hinder the detection of publication bias using conventional methods like funnel plots. Additionally, the methodological heterogeneity among the studies complicated the interpretation of the distribution of effect sizes. To overcome these challenges, the authors employed the fail-safe value method instead of the funnel plot technique to evaluate potential publication bias.

By using the fail-safe value method, the authors provided a transparent and comprehensive assessment of potential publication bias while accounting for the unique characteristics of the included studies. The calculated fail-safe value of 83 demonstrated the robustness of their meta-analytic findings, indicating that a substantial number of unpublished studies with null results would be required to negate the positive outcomes reported in their study.

Moreover, the overall consistency in study outcomes, with 16 out of 18 studies showing a statistically significant positive impact of DGBL on primary school students' knowledge acquisition in STEM subjects, further supported the effectiveness of DGBL in this context.

6.6. Contributions to the Field of DGBL

The present meta-analysis significantly contributes to the field of DGBL in primary education by:

- Consolidating evidence from 18 studies on the impact of DGBL on primary school students' learning outcomes in STEM subjects.
- Identifying the most effective types of DGBL and guiding educators in choosing appropriate game types to improve learning outcomes.
- Evaluating the effectiveness of different gaming platforms, such as computers and mobile devices, to help educators make informed decisions.
- Examining how intervention duration affects learning outcomes and providing insights into the ideal length of DGBL interventions.

- Emphasizing the role of DGBL in developing critical STEM skills and knowledge among primary school students.
- Identifying research trends and gaps to encourage further research and inform the development of more effective educational strategies.
- Offering practical guidance for educators and policymakers implementing DGBL in primary education, with recommendations on game types, platforms, intervention duration, and subject areas to improve learning outcomes and enhance educational experiences for students.

By addressing these aspects, the meta-analysis substantially contributes to the existing body of knowledge on DGBL in primary education and offers valuable insights to advance research and educational practices in STEM education.

6.7. Implications

The outcomes of this comprehensive study bear wide-ranging implications for diverse stakeholders within the STEM education ecosystem:

- **Educational Practice:** The results of this meta-analysis substantiate the efficacy of DGBL in augmenting students' learning outcomes in STEM disciplines. Educators can harness these insights to recalibrate their pedagogical methodologies, integrating DGBL into their STEM curricula to catalyze student engagement and optimize learning.
- **Game Developers:** The significance of refined game design and mechanics, as highlighted by the study, underscores the potential for game developers to engineer or refine DGBL with heightened educational efficacy and learner engagement. By addressing unique learning requirements and incorporating research-driven strategies, game developers can contribute to the advancement of STEM education.
- **Policy and Decision Makers:** The evidence-driven conclusions of this study can guide policymakers in formulating policies that promote investments in DGBL, advocate for the adoption of emerging technologies, and incentivize ongoing research in DGBL within STEM education. Policy decisions integrating DGBL as tools for elevating learning outcomes can incite enduring, positive transformations in education systems.
- **Researchers:** The identification of critical research domains within the realm of DGBL in STEM learning serves as a roadmap for researchers aiming to contribute to this burgeoning field. By pursuing evidence-based investigations and encouraging collaboration among education, technology, and design specialists, researchers can reshape the future of STEM education.
- **Students and Parents:** With the study establishing the potency of DGBL in bolstering academic outcomes, students and parents can consider assimilating these games into home-based learning pursuits. This incorporation not only supports STEM learning beyond traditional classroom settings but also cultivates affirmative attitudes towards technology and learning among young scholars.

7. CONCLUSIONS

This meta-analysis aims to explore the impact of DGBL on the academic achievement of primary school students in STEM subjects. Through a comprehensive analysis of 18 research studies, the study reveals a moderate yet positive effect of DGBL on learning outcomes, suggesting that these games have the potential to significantly enhance academic achievement when compared to traditional teaching methods. Furthermore, the study delves into the intricacies of DGBL by examining the influence of factors such as subject disciplines, control treatment, game type, platforms, and intervention duration on learning outcomes. The results indicate that integrating educational DGBL into STEM education can serve as a valuable teaching strategy, leading to measurable improvements in academic performance.

7.1. Limitations

This research investigation examines the potential advantages of incorporating educational DGBL into STEM education in primary schools, comparing their effectiveness to that of non-digital games. Despite its contributions, this meta-analysis has certain limitations. Firstly, the meta-analysis methodology required excluding relevant studies that did not meet specific criteria, resulting in the analysis relying on data from 18 empirical studies and effect estimates, while other pertinent studies may have been overlooked. Secondly, a random-effects model was employed instead of a more precise fixed-effects model. Furthermore, a comprehensive examination of all internal and external moderator variables was not feasible within the study's scope. Additionally, there is a noticeable gap in research investigating the impact of DGBL on cognitive abilities and emotional states. In light of these limitations, it is recommended that future research utilize diverse academic databases to explore the effects of DGBL with STEM instruction from multiple perspectives, particularly in primary school settings.

7.2. Future Work and Recommendations

As more studies on DGBL in primary STEM education become available, future meta-analyses should employ additional methods such as funnel plots, Egger's regression test, and trim-and-fill analysis to further explore potential biases and variability in publications.

Future research should focus on identifying the ideal duration for DGBL interventions in primary STEM education, considering factors such as game type, subject area, and student demographics. This will help educators and policymakers make informed decisions when implementing DGBL interventions in their curricula.

Further investigation into the potential of combining different gameplay designs to create a more holistic and effective learning experience is also encouraged. By considering the unique advantages of various game types and platforms, educators can optimize the use of DGBL in primary STEM education and foster a more engaging and collaborative learning environment.

In addition, future studies should delve deeper into the factors contributing to disciplinary differences in learning outcomes. This knowledge can be used to develop customized DGBL interventions that cater to the specific learning needs of each subject area.

Lastly, incorporating personalized learning strategies into DGBL designs, as well as investigating the integration of DGBL with other technologies, can further enhance the potential benefits of these interventions in primary education.

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9. REFERENCES

Al-Azawi, R., Al-Obaidy, M., Ayesh, A., & Rosenburg, D. (2016). The impact of using educational gamification in mobile computing course: A case study. In *Communication, Management and Information Technology* (pp. 249-254). CRC Press.

Anderson, J., & Barnett, M. (2011). Using video games to support pre-service elementary teachers learning of basic physics principles. *Journal of Science Education and Technology*, *20*, 347-362. https://doi.org/10.1007/s10956-010-9257-0

Arztmann, M., Hornstra, L., Jeuring, J., & Kester, L. (2023). Effects of games in STEM education: a meta-analysis on the moderating role of student background characteristics. *Studies in Science Education*, *59*(1), 109-145. https://doi.org/10.1080/03057267.2022.2057732

Bai, S., Hew, K. F., & Huang, B. (2020). Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. *Educational Research Review*, *30*, 100322. https://doi.org/10.1016/j.edurev.2020.100322

Begg, C. B., & Mazumdar, M. (1994). Operating characteristics of a rank correlation test for publication bias. *Biometrics, 50* (4), 1088-1101.

Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, S. A. (2023). A review of using digital game-based learning for preschoolers. *Journal of Computers in Education*, *10*(4), 603-636. https://doi.org/10.1007/s40692-022-00240-0

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research synthesis methods*, *1*(2), 97-111. https://doi.org/10.1002/jrsm.12

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2021). *Introduction to meta-analysis*. John Wiley & Sons.

Borgman, C. L., Abelson, H., Dirks, L., Johnson, R., Koedinger, K. R., Linn, M. C., Lynch, C. A., Oblinger, D. G., Pea, R. D., & Salen, K. (2008). Fostering learning in the networked world: The cyberlearning opportunity and challenge. A 21st century agenda for the National Science Foundation. NSF. https://www.nsf.gov/pubs/2008/nsf08204/nsf08204.pdf

Brinson, J. R. (2015). Learning outcome achievement in non-traditional (virtual and remote) versus traditional (hands-on) laboratories: A review of the empirical research. *Computers & Education*, *87*, 218-237. https://doi.org/10.1016/j.compedu.2015.07.003

Chang, C.-Y., & Hwang, G.-J. (2019). Trends in digital game-based learning in the mobile era: A systematic review of journal publications from 2007 to 2016. *International Journal of Mobile Learning and Organisation*, *13*(1), 68-90. https://doi.org/10.1504/IJMLO.2019.096468

Charsky, D., & Ressler, W. (2011). "Games are made for fun": Lessons on the effects of concept maps in the classroom use of computer games. *Computers & education*, *56*(3), 604-615. https://doi.org/10.1016/j.compedu.2010.10.001

Chen, C.-H. (2020). Impacts of augmented reality and a digital game on students' science learning with reflection prompts in multimedia learning. *Educational Technology Research and Development*, *68*(6), 3057-3076. https://doi.org/10.1007/s11423-020-09834-w

Chen, C.-H., Shih, C.-C., & Law, V. (2020). The effects of competition in digital game-based learning (DGBL): a meta-analysis. *Educational Technology Research and Development*, *68*, 1855-1873. https://doi.org/10.1007/s11423-020-09794-1

Chen, C. H., Liu, G. Z., & Hwang, G. J. (2016). Interaction between gaming and multistage guiding strategies on students' field trip mobile learning performance and motivation. *British journal of educational technology*, *47*(6), 1032-1050. https://doi.org/10.1111/bjet.12270

Chen, J., Wang, M., Kirschner, P. A., & Tsai, C.-C. (2018). The role of collaboration, computer use, learning environments, and supporting strategies in CSCL: A meta-analysis. *Review of educational research*, *88*(6), 799-843. https://doi.org/10.3102/0034654318791584

Chiappe, A., Amado, N., & Leguizamón, L. (2020). Educommunication in digital environments: an interaction´s perspective inside and beyond the classroom. Innoeduca. *International Journal of Technology and Educational Innovation, 6*(1), 34-41.

Chu, H.-C., & Chang, S.-C. (2014). Developing an educational computer game for migratory bird identification based on a two-tier test approach. *Educational Technology Research and Development*, *62*, 147-161. https://doi.org/10.1007/s11423-013-9323-4

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. Academic press.

Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers & education, 59*(2), 661-686. https://doi.org/10.1016/j.compedu.2012.03.004

Corredor, J., Gaydos, M., & Squire, K. (2014). Seeing change in time: Video games to teach about temporal change in scientific phenomena. *Journal of Science Education and Technology*, *23*, 324-343. https://psycnet.apa.org/doi/10.1007/s10956-013-9466-4

Egger, M., Smith, G. D., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *Bmj*, *315*(7109), 629-634. https://doi.org/10.1136/bmj.315.7109.629

Erhel, S., & Jamet, E. (2013). Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. *Computers & education*, *67*, 156-167. https://doi.org/10.1016/j.compedu.2013.02.019

Gao, F., Li, L., & Sun, Y. (2020). A systematic review of mobile game-based learning in STEM education. *Educational Technology Research and Development*, *68*, 1791-1827. https://doi.org/10.1007/s11423-020-09787-0

Gao, X., Li, P., Shen, J., & Sun, H. (2020). Reviewing assessment of student learning in interdisciplinary STEM education. *International Journal of STEM Education*, *7*(1), 1-14. https://doi.org/10.1186/s40594-020-00225-4

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: A research and practice model. *Simulation & gaming*, *33*(4), 441-467. https://doi.org/10.1177/1046878102238607

Garzón, J., & Acevedo, J. (2019). Meta-analysis of the impact of Augmented Reality on students' learning gains. *Educational Research Review*, *27*, 244-260. https://doi.org/10.1016/j.edurev.2019.04.001

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in entertainment (CIE)*, *1*(1), 20-20. https://doi.org/10.1145/950566.950595

Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education*, *68*, 429-439. https://doi.org/10.1016/j.compedu.2013.06.005

Glass, G. V., McGaw, B., & Smith, M. L. (1981). *Meta-analysis in social research*. Sage Publications.

Guan, X., Sun, C., Hwang, G.-j., Xue, K., & Wang, Z. (2024). Applying game-based learning in primary education: A systematic review of journal publications from 2010 to 2020. *Interactive Learning Environments*, *32*(2), 534-556. https://doi.org/10.1080/10494820.2022.2091611

Gui, Y., Cai, Z., Yang, Y., Kong, L., Fan, X., & Tai, R. H. (2023). Effectiveness of digital educational game and game design in STEM learning: a meta-analytic review. *International Journal of*

STEM Education, *10*(1), 1-25. https://doi.org/10.1186/s40594-023-00424-9

Habgood, M. J., & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *The Journal of the Learning Sciences*, *20*(2), 169-206. https://doi.org/10.1080/10508406.2010.508029

Haidar, F. (2024). An Effect of Assessment Delivery Methods on Accounting Students' Grades in an E-learning Environment. Innoeduca. *International Journal of Technology and Educational Innovation, 10*(1), 65-80. https://doi.org/10.24310/ijtei.101.2024.17672

Hayati, S., & Behnamnia, N. (2023). Exploring game behavior, scaffolding, and learning mathematics in digital game-based learning apps on children. *Journal of Modern Educational Research, 2*(5). https://doi.org/10.53964/jmer.2023005

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *Bmj*, *327*(7414), 557-560. https://doi.org/10.1136/bmj.327.7414.557

Hodges, G. W., Flanagan, K., Lee, J., Cohen, A., Krishnan, S., & Ward, C. (2020). A quasi-experimental study comparing learning gains associated with serious educational gameplay and hands-on science in elementary classrooms. *Journal of Research in Science Teaching*, *57*(9), 1460-1489. https://doi.org/10.1002/tea.21661

Homer, B. D., Raffaele, C., & Henderson, H. (2020). Games as playful learning: Implications of developmental theory for game-based learning. *Handbook of game-based learning*, 25-52.

Hong, J. C., Cheng, C. L., Hwang, M. Y., Lee, C. K., & Chang, H. Y. (2009). Assessing the educational values of digital games. *Journal of computer assisted learning*, *25*(5), 423-437. https://psycnet.apa.org/doi/10.1111/j.1365-2729.2009.00319.x

Huang, K., Bryant, T., & Schneider, B. (2019). Identifying Collaborative Learning States Using Unsupervised Machine Learning on Eye-Tracking, Physiological and Motion Sensor Data. In C.F. Lynch, A. Merceron, M. Desmarais & R. Nkambou (Eds.), *Proceedings of the 12th International Conference on Educational Data Mining* (pp.318-323). International Educational Data Mining Society.

Hung, C.-M., Huang, I., & Hwang, G.-J. (2014). Effects of digital game-based learning on students' self-efficacy, motivation, anxiety, and achievements in learning mathematics. *Journal of Computers in Education*, *1*, 151-166. https://doi.org/10.1007/s40692-014-0008-8

Hung, H.-T., Yang, J. C., Hwang, G.-J., Chu, H.-C., & Wang, C.-C. (2018). A scoping review of research on digital game-based language learning. *Computers & Education*, *126*, 89-104. https://psycnet.apa.org/doi/10.1016/j.compedu.2018.07.001

Hwang, G.-J., Wu, P.-H., & Chen, C.-C. (2012). An online game approach for improving students' learning performance in web-based problem-solving activities. *Computers & Education*, *59*(4), 1246-1256. https://doi.org/10.1016/j.compedu.2012.05.009

Hwang, G.-J., Wu, P.-H., Chen, C.-C., & Tu, N.-T. (2016). Effects of an augmented reality-based educational game on students' learning achievements and attitudes in real-world observations. *Interactive Learning Environments*, *24*(8), 1895-1906. https://doi.org/10.1080/10494820.2015.1057747

Hwang, G. J., Sung, H. Y., Hung, C. M., Yang, L. H., & Huang, I. (2013). A knowledge engineering approach to developing educational computer games for improving students' differentiating knowledge. *British journal of educational technology*, *44*(2), 183-196. https://doi.org/10.1111/j.1467-8535.2012.01285.x

Jia, Y., Xu, B., Karanam, Y., & Voida, S. (2016). Personality-targeted gamification: a survey study on personality traits and motivational affordances. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* (pp.2001-2013). Association for computing machinery. https://doi.org/10.1145/2858036.2858515

Ke, F. (2019). Mathematical problem solving and learning in an architecture-themed epistemic game. *Educational Technology Research and Development*, *67*(5), 1085-1104. https://doi.org/10.1007/s11423-018-09643-2

Khan, A., Ahmad, F. H., & Malik, M. M. (2017). Use of digital game based learning and gamification in secondary school science: The effect on student engagement, learning and gender difference. *Education and Information Technologies*, *22*, 2767-2804. https://doi.org/10.1007/s10639-017-9622-1

Kickmeier-Rust, M. D., Hockemeyer, C., Albert, D., & Augustin, T. (2008). Micro adaptive, non-invasive knowledge assessment

in educational games. *2008 Second IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning* (pp. 135-137). https://doi.org/10.1109/DIGITEL.2008.10

Kiili, K. (2005). Digital game-based learning: Towards an experiential gaming model. *The Internet and higher education*, *8*(1), 13-24. https://doi.org/10.1016/j.iheduc.2004.12.001

Kim, H., & Ke, F. (2017). Effects of game-based learning in an OpenSim-supported virtual environment on mathematical performance. *Interactive Learning Environments*, *25*(4), 543-557. https://psycnet.apa.org/doi/10.1080/10494820.2016.1167744

Li, M.-C., & Tsai, C.-C. (2013). Game-based learning in science education: A review of relevant research. *Journal of Science Education and Technology*, *22*, 877-898. https://doi.org/10.1007/s10956-013-9436-x

Li, Y., Froyd, J. E., & Wang, K. (2019). Learning about research and readership development in STEM education: A systematic analysis of the journal's publications from 2014 to 2018. *International Journal of STEM Education*, *6*, 1-8. https://doi.org/10.1186/s40594-019-0176-1

Lin, C.-H., Liu, E. Z.-F., Chen, Y.-L., Liou, P.-Y., Chang, M., Wu, C.-H., & Yuan, S.-M. (2013). Game-based remedial instruction in mastery learning for upper-primary school students. *Journal of Educational Technology & Society*, *16*(2), 271-281.

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis*. SAGE publications.

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. *Computers & Education*, *70*, 29-40. https://doi.org/10.1016/j.compedu.2013.07.033

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Group, P. (2010). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *International journal of surgery*, *8*(5), 336-341. https://doi.org/10.1371/journal.pmed.1000097

Moher, D., Shamseer, L., Clarke, M., Ghersi, D., Liberati, A., Petticrew, M., Shekelle, P., Stewart, L. A., & Group, P.-P. (2015). Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015 statement. *Systematic reviews*, *4*, 1-9. https://doi.org/10.1186/2046-4053-4-1

Neimeyer, S. A. (2006). *An examination of the effects of computer-assisted educational games on student achievement*. University of Houston-Clear Lake.

Noble Jr, J. H. (2006). Meta-analysis: methods, strengths, weaknesses, and political uses. *Journal of Laboratory and Clinical Medicine*, *147*(1), 7-20. https://doi.org/10.1016/j.lab.2005.08.006

Oguguo, B., Ezechukwu, R., Nannim, F., & Offor, K. (2023). Analysis of teachers in the use of digital resources in online teaching and assessment in COVID times. Innoeduca. International Journal of Technology and Educational Innovation, 9(1), 81-96. https://doi.org/10.24310/innoeduca.2023.v9i1.15419

Onyekwere, J., & Hoque, K. E. (2023). Relationship between technological change, digitization, and students' attitudes toward distance learning in Lagos Higher Education institutes. Innoeduca. International Journal of Technology and Educational Innovation, 9(1), 126-142. https://doi.org/10.24310/innoeduca.2023.v9i1.15286

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers & education*, *52*(1), 1-12. https://doi.org/10.1016/j.compedu.2008.06.004

Paré, G., Trudel, M.-C., Jaana, M., & Kitsiou, S. (2015). Synthesizing information systems knowledge: A typology of literature reviews. *Information & Management*, *52*(2), 183-199. https://doi.org/10.1016/j.im.2014.08.008

Prakasha, G. S., Rangasamy, S., Jahnavitha, V., & Dlima, S. (2024). Students' usage of Over-the-top (OTT) streaming platforms affecting their academic and socio-demographic profile. *Innoeduca. International Journal of Technology and Educational Innovation, 10*(1), 124-143. https://doi.org/10.24310/ijtei.101.2024.17082

Plass, J. L., Homer, B. D., & Kinzer, C. K. (2015). Foundations of game-based learning. *Educational psychologist*, *50*(4), 258-283. https://doi.org/10.1080/00461520.2015.1122533

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research. *Computers*

in human behavior, *63*, 50-58. https://doi.org/10.1016/j.chb.2016.05.023

Romero, M., & Barma, S. (2015). Teaching pre-service teachers to integrate Serious Games in the primary education curriculum. *International Journal of Serious Games*, *2*(1). https://doi.org/10.17083/ijsg.v2i1.43

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological bulletin*, *86*(3), 638. https://psycnet.apa.org/doi/10.1037/0033-2909.86.3.638

Sedig, K. (2008). From play to thoughtful learning: A design strategy to engage children with mathematical representations. *Journal of Computers in Mathematics and Science Teaching*, *27*(1), 65-101.

Shaffer, D. W. (2006). Epistemic frames for epistemic games. *Computers & education*, *46*(3), 223-234. https://doi.org/10.1016/j.compedu.2005.11.003

Solanes, J. E., Montava-Jordà, S., Golf-Laville, E., Colomer-Romero, V., Gracia, L., & Muñoz, A. (2023). Enhancing STEM Education through Interactive Metaverses: A Case Study and Methodological Framework. *applied sciences*, *13*(19), 10785. https://doi.org/10.3390/app131910785

Squire, K. (2006). From content to context: Videogames as designed experience. *Educational researcher*, *35*(8), 19-29. https://doi.org/10.3102/0013189X035008019

Stege, L., van Lankveld, G., & Spronck, P. (2012). Teaching high school physics with a serious game. *International Journal of Computer Science in Sport*, *11*(1), 123-134.

Su, C.-H., & Cheng, C.-H. (2013). A mobile game-based insect learning system for improving the learning achievements. *Procedia-Social and Behavioral Sciences*, *103*, 42-50. https://doi.org/10.1016/j.sbspro.2013.10.305

Sung, H.-Y., & Hwang, G.-J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & education*, *63*, 43-51. https://doi.org/10.1016/j.compedu.2012.11.019

Thompson, C. G., & von Gillern, S. (2020). Video-game based instruction for vocabulary acquisition with English language learners: A Bayesian meta-analysis. *Educational Research Review*, *30*, 100332. https://doi.org/10.1016/j.edurev.2020.100332

Tokac, U., Novak, E., & Thompson, C. G. (2019). Effects of game-based learning on students' mathematics achievement: A meta-analysis. *Journal of computer assisted learning*, *35*(3), 407-420. https://doi.org/10.1111/jcal.12347

Tsai, Y. L., & Tsai, C. C. (2020). A meta-analysis of research on digital game-based science learning. *Journal of computer assisted learning*, *36*(3), 280-294. https://doi.org/10.1111/jcal.12430

van der Ven, F., Segers, E., Takashima, A., & Verhoeven, L. (2017). Effects of a tablet game intervention on simple addition and subtraction fluency in first graders. *Computers in Human Behavior*, *72*, 200-207. https://doi.org/10.1016/j.chb.2017.02.031

Videnovik, M., Vold, T., Kiønig, L., Madevska Bogdanova, A., & Trajkovik, V. (2023). Game-based learning in computer science education: a scoping literature review. *International Journal of STEM Education*, *10*(1), 54. https://doi.org/10.1186/s40594-023-00447-2

Wahono, B., Lin, P.-L., & Chang, C.-Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*, 1-18. https://doi.org/10.1186/s40594-020-00236-1

Wang, C.-p., Lan, Y.-J., Tseng, W.-T., Lin, Y.-T. R., & Gupta, K. C.-L. (2020). On the effects of 3D virtual worlds in language learning–a meta-analysis. *Computer Assisted Language Learning*, *33*(8), 891-915. https://doi.org/10.1080/09588221.2019.1598444

Wang, L.-H., Chen, B., Hwang, G.-J., Guan, J.-Q., & Wang, Y.-Q. (2022). Effects of digital game-based STEM education on students' learning achievement: a meta-analysis. *International Journal of STEM Education*, *9*(1), 1-13. https://doi.org/10.1186/s40594-022-00344-0

Wouters, P., Van Nimwegen, C., Van Oostendorp, H., & Van Der Spek, E. D. (2013). A meta-analysis of the cognitive and motivational effects of serious games. *Journal of educational psychology*, *105*(2), 249. https://doi.org/10.1037/a0031311

Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., & Huang, S. H. (2012). Investigating the learning-theory foundations of game-based learning: a meta-analysis. *Journal of computer assisted learning*, *28*(3), 265-279. https://doi.org/10.1111/j.1365-2729.2011.00437.x

Yallihep, M., & Kutlu, B. (2020). Mobile serious games: Effects on students' understanding of programming concepts and attitudes towards information technology. *Education and Information Technologies*, *25*(2), 1237-1254. https://doi.org/10.1007/s10639-019-10008-2

Yu, Q., Yu, K., & Li, B. (2024). Can gamification enhance online learning? Evidence from a meta-analysis. *Education and Information Technologies*, *29*(4), 4055-4083. https://doi.org/10.1007/s10639-023-11977-1

Zeng, H., Zhou, S.-N., Hong, G.-R., Li, Q.-y., & Xu, S.-Q. (2020). Evaluation of Interactive Game-Based Learning in Physics Domain. *Journal of Baltic Science Education*, *19*(3), 484-498. http://dx.doi.org/10.33225/jbse/20.19.484

Zhang, L., Shang, J., Pelton, T., & Pelton, L. F. (2020). Supporting primary students' learning of fraction conceptual knowledge through digital games. *Journal of Computer Assisted Learning*, *36*(4), 540-548. https://doi.org/10.1111/jcal.12422

Zheng, Y., Zhang, J., Li, Y., Wu, X., Ding, R., Luo, X., Liu, P., & Huang, J. (2024). Effects of digital game-based learning on students' digital etiquette literacy, learning motivations, and engagement. *Heliyon*, *10*(1). https://doi.org/10.1016/j.heliyon.2023.e23490

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The dynamics of disposition: introducing a new scale for evaluating middle school attitudes towards blended learning

La dinámica de la disposición: introduciendo una nueva escala para evaluar las actitudes de los estudiantes de secundaria hacia el aprendizaje híbrido

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ABSTRACT

This study was conducted to develop and validate a reliable measurement tool that assesses middle-school students' attitudes towards blended learning methods. The research process began with a comprehensive literature review, resulting in a preliminary 42-item draft scale. This scale was administered to 259 seventh-grade students attending a public school in Izmir, Türkiye. The content validity of the scale was rigorously evaluated through expert opinions, ensuring its relevance and appropriateness. To establish the construct validity, both exploratory and confirmatory factor analyses were conducted. The analyses refined the scale to 36 items distributed across a two-factor structure, with the first and second factors comprising 22 positive and 14 negative items, respectively. These factors together accounted for 57.035% of the total variance, indicating a significant representation of the construct. The scale demonstrated excellent statistical robustness, evidenced by a Kaiser-Meyer-Olkin value of .943 and a significant Bartlett's test of sphericity. Furthermore, the scale's reliability was confirmed through a Cronbach's alpha of .847, underscoring its consistency and stability as a measurement tool. The results affirm that the developed scale is both valid and reliable for measuring middle school students' attitudes towards blended learning, providing valuable insights for educational strategies and technological integration. This scale equips educators and policymakers with a powerful tool to tailor educational approaches that enhance student engagement and learning outcomes in blended learning environments.

KEYWORDS Blended learning; attitude measurement; scale development; middle school education.

RESUMEN

Este estudio se realizó para desarrollar y validar una herramienta de medición confiable que evalúa las actitudes de los estudiantes de secundaria hacia los métodos de aprendizaje híbrido. El proceso de investigación comenzó con una revisión exhaustiva de la literatura, resultando en una escala preliminar de 42 ítems. Esta escala se administró a 259 estudiantes de séptimo grado de una escuela pública en Izmir, Turquía. La validez de contenido de la escala fue rigurosamente evaluada

a través de opiniones de expertos, asegurando su relevancia y adecuación. Para establecer la validez de constructo, se llevaron a cabo análisis factoriales exploratorios y confirmatorios. Los análisis refinaron la escala a 36 ítems distribuidos en una estructura de dos factores, con los primeros y segundos factores que comprenden 22 ítems positivos y 14 ítems negativos, respectivamente. Estos factores juntos representaron el 57.035% de la varianza total, indicando una representación significativa del constructo. La escala demostró una robustez estadística excelente, evidenciada por un valor de Kaiser-Meyer-Olkin de .943 y una prueba de esfericidad de Bartlett significativa. Además, la confiabilidad de la escala se confirmó a través de un alfa de Cronbach de .847, subrayando su consistencia y estabilidad como herramienta de medición. Los resultados afirman que la escala desarrollada es válida y confiable para medir las actitudes de los estudiantes de secundaria hacia el aprendizaje híbrido, proporcionando información valiosa para estrategias educativas e integración tecnológica. Esta escala equipa a los educadores y responsables políticos con una herramienta poderosa para adaptar enfoques educativos que mejoren el compromiso y los resultados de aprendizaje de los estudiantes en entornos de aprendizaje híbrido.

PALABRAS CLAVE Aprendizaje híbrido; medición de actitudes; desarrollo de escalas; educación de secundaria.

1. INTRODUCTION

Blended learning, combining face-to-face instruction with web-assisted learning, has become a transformative educational approach for the information age (Dangwal, 2017). Blended learning includes virtual classrooms, personalized training, collaborative learning, and multimedia resources, creating a rich learning environment (Ashraf et al., 2021). It enhances accessibility and flexibility, catering to diverse learning preferences and paces (Chaw & Tang, 2023). Virtual classrooms allow engagement from anywhere, while personalized training lets learners progress at their own pace with tailored support (Kilag et al., 2023). Online platforms foster teamwork and communication skills essential for the modern workforce (Bizami et al., 2023). Multimedia resources such as videos and interactive simulations cater to various learning styles (Akram et al., 2023). Despite the advantages of online learning, face-to-face interaction remains crucial for feedback, hands-on activities, and interpersonal skills development (Bizami et al., 2023). This combination makes blended learning effective for modern education, addressing limitations of purely online or traditional settings (Smith & Hill, 2018). Adaptability and inclusivity of blended learning meet the evolving needs of students, leveraging technology to enhance traditional practices and develop critical 21st-century skills (Dakhi et al., 2020). It prepares students to thrive in a digital world, fulfilling education's goal of equipping individuals with essential skills for the information society.

Understanding students' attitudes towards blended learning is crucial, as these attitudes significantly influence educational outcomes (Cao, 2023). Positive attitudes lead to better engagement and results, while negative attitudes can hinder progress (Zhang et al., 2020). Educators must measure and analyze these attitudes to fine-tune educational strategies and align them with learner preferences (Chiu, 2021). This approach ensures that blended learning techniques enhance the learning experience, supporting the goal of equipping students with skills for the digital age. The Community of Inquiry (CoI) framework supports this understanding by conceptualizing the online educational experience through social, cognitive, and teaching presences, which are critical to creating a deep and meaningful learning experience. Incorporating technology in education offers advantages like enhanced social development, independent learning, better motivation, and increased network literacy (Kikalishvili, 2023; Stec et al., 2020). However, effective education

requires purposeful and strategic application of technology, involving educators, students, families, and administrators (Blau & Hameiri, 2017). Teachers must integrate technology into their strategies, and students should take responsibility for their learning (ElSayary, 2023). Support from families and administrators is also crucial (Khlaif et al., 2023).

Despite the growing importance of blended learning, there remains a significant gap in the research regarding robust measurement tools specifically designed to assess middle school students' attitudes towards blended learning methods. While numerous studies have explored the general perceptions within blended learning environments, they have largely overlooked the critical dimension of student attitudes (Banihashem et al., 2023; Niu et al., 2023; Olpak & Ateş, 2018; Peng et al., 2023). The attitudes of students towards blended learning are pivotal as they directly impact their engagement, motivation, and overall success in these environments (Ateş & Garzon, 2022, 2023). Positive attitudes are linked to enhanced learning experiences and outcomes, while negative attitudes can significantly hinder educational progress (Cao, 2023). However, existing studies typically rely on subjective evaluations rather than rigorously validated measurement tools, resulting in inconsistent and unreliable data. This deficiency underscores the need for methodically developed tools that can provide accurate and actionable insights into students' attitudes. Such tools are essential for educators to effectively tailor and optimize blended learning environments, ensuring they cater to the diverse needs and preferences of students.

The study aims to address this gap by developing and validating an attitude scale specifically for middle school students engaged in blended learning. This scale is intended to measure students' perceptions accurately, thereby informing the adaptation and enhancement of teaching strategies to improve educational outcomes. Providing educators with a reliable tool to assess attitudes towards blended learning is critical for integrating educational technology more effectively and for advancing pedagogical practices.

Research Questions:

1. **How reliable is the newly developed attitude scale for measuring middle school students' perceptions of blended learning?**

   This question is crucial as reliability determines the consistency of the scale across different contexts and samples. Establishing reliability is fundamental to ensuring that the scale produces stable and repeatable results, which is essential for its application in diverse educational settings.

2. **Does the attitude scale exhibit valid construct representation for attitudes toward blended learning among middle school students?**

   This question seeks to validate the scale's effectiveness in capturing the complex attitudes students hold towards blended learning. Validity is key to confirming that the scale accurately measures the constructs it purports to measure, thereby providing meaningful and trustworthy data that can guide educational decisions and strategies.

2. LITERATURE REVIEW

Blended learning, also known as hybrid learning, is an educational approach that seamlessly integrates traditional face-to-face classroom instruction with online learning components to create a balanced educational experience (Dangwal, 2017). This method combines the engaging and personalized aspects of in-person teaching with the flexibility and accessibility of online formats (Singh et al., 2021). Key aspects of blended learning include direct student-instructor interactions essential for engagement and feedback; online learning materials such as multimedia lectures, interactive simulations, and digital textbooks that students can access at their convenience; interactive technologies like discussion forums, blogs, and collaborative platforms that foster active learning and teamwork; and a variety of assessment methods that provide both traditional and immediate digital feedback (Armellini et al., 2021; Ateş, 2024; López-Pellisa et al., 2021). This holistic approach ensures that blended learning adapts to diverse learning styles and needs, enhancing both the effectiveness and reach of educational programs.

In the evolving landscape of blended learning, a variety of studies have enriched our understanding of the factors that influence its effectiveness and acceptance, guiding the development of comprehensive items for a new scale intended to measure these elements. One of them conducted by Akkoyunlu and Yılmaz-Soylu (2008) developed a refined scale consisting of 50 items, revealing two principal components that elucidate learners' views on blended learning and its implementation. This scale underscores the complexity levels of the learning process and the nuanced views of learners towards blended modalities, setting a precedent for comprehensive scale development in this educational context. Building on these insights, Bervell et al. (2021) constructed the Blended Learning Acceptance Scale (BLAS) which integrates perceptions of both LMS-based online learning and face-to-face components. Their research highlights the need for a holistic approach to measuring blended learning acceptance, reflecting both digital and traditional educational experiences. Furthermore, Bhagat et al. (2023) employed exploratory and confirmatory factor analysis to develop a scale that captures three dimensions of blended learning experiences among students in Malaysia: course design, learning experience, and personal factors. This robust validation ensures that the scale reliably reflects varied aspects of student interaction with blended learning environments. In a similar vein, Lazar et al. (2020) introduced a multidimensional scale focusing on the acceptance of digital technology in blended learning contexts. Their work emphasizes the role of familiarity with digital tools, identifying it as a significant factor influencing learners' engagement with technology in blended settings. The study by Han and Ellis (2020) highlighted the importance of understanding student perceptions in blended learning environments. They developed the Perceptions of the Blended Learning Environment Questionnaire (PBLEQ), which is distinguished by its bifactor model assessing integration between different learning modalities and the specific contributions of online components. Lastly, Çemçem et al. (2024) addressed the need for assessing teachers' readiness for blended learning. Their scale, derived from exploratory and confirmatory factor analysis, reflects a nuanced understanding of the pedagogical, technological, and adaptive skills required for effective blended teaching. These studies collectively underscore the multifaceted nature of blended learning environments. They reveal that effective assessment tools must not only address the technological aspects but also the pedagogical and interpersonal dynamics that influence both learners' and instructors' experiences. The comprehensive scales developed in these studies provide a robust framework

for evaluating the effectiveness of blended learning implementations and offer insights that could guide future enhancements in this educational paradigm.

To integrate findings from the aforementioned studies into a coherent framework for item formation in a new blended learning scale, Table 1 was presented, aligning specific research findings with corresponding scale items.

TABLE 1. Systematic Alignment of Research Insights with Scale Item Development for Blended Learning

STUDY AUTHORS	KEY FINDINGS	INFLUENCED SCALE ITEMS
Akkoyunlu & Yılmaz-Soylu (2008)	Identified two principal components crucial for understanding learners' views on blended learning.	Items to assess learners' perceptions of the complexity and effectiveness of blended learning integration.
Bervell et al. (2021)	Developed BLAS to combine both LMS-based and face-to-face learning acceptance.	Items that measure acceptance and adaptability to both online platforms and traditional classroom settings.
Bhagat et al. (2023)	Explored three dimensions: course design, learning experience, and personal factors affecting blended learning.	Items covering course structure, interactive elements, and personal engagement with blended learning courses.
Lazar et al. (2020)	Extended Technology Acceptance Model to include familiarity with digital tools and their impact on blended learning acceptance.	Items to evaluate familiarity with and attitudes towards various digital tools used in blended learning.
Han & Ellis (2020)	Developed PBLEQ focusing on integration between learning modalities and the contributions of online components.	Items assessing the integration effectiveness and student perceptions of online contributions to learning outcomes.
Çemçem et al. (2024)	Assessed teachers' readiness for blended learning, emphasizing pedagogical, technological, and adaptive skills.	Items designed to gauge teacher preparedness and competency in managing blended learning environments.

3. MATERIAL AND METHOD

3.1. Study Group

The study sample comprised 259 seventh-grade students enrolled in a public school in Izmir in Turkey during the 2018-2019 academic year. These participants were chosen through the convenience sampling method, a technique favored for its efficiency and practicality. This method enables researchers to quickly gather data from a readily available subset of the population, thereby facilitating the timely progression of the study without compromising the validity of the results (Çobanoğlu & Demir, 2023).

3.2. Scale Development Process

This research aimed to accurately gauge middle school students' attitudes towards blended learning methods through a meticulously crafted scale developed in five comprehensive phases.

3.2.1. Item Formation Phase

The item formation phase initiated this process by conducting an extensive review of the literature on blended learning methods to establish a solid theoretical foundation. Central to this foundation was the Community of Inquiry (CoI) framework, which identifies three pivotal elements—social presence, cognitive presence, and teaching presence—as essential to fostering a meaningful and effective educational experience in blended learning environments. The application of the CoI framework guided the development of the scale's items. For social presence, the scale included questions designed to assess students' perceptions of their connectedness and social integration within the blended learning environment. These items explored aspects such as the sense of community, ease of interaction with peers, and students' comfort levels in expressing themselves in virtual settings. In assessing cognitive presence, the scale focused on how students construct and confirm meaning through reflection and discourse. Items were crafted to measure the depth of engagement with the content, the quality of critical thinking displayed, and the ability to integrate and apply the knowledge gained in a blended setting. Teaching presence was evaluated through items that examined the design, organization, facilitation, and direction of the educational activities and content delivery. This included assessing the effectiveness of instructional methods and the level of educator support provided in both online and face-to-face components of blended learning. The insights gained from these theoretical and practical considerations were transformed into a preliminary set of 42 distinct items. These were designed to capture a broad spectrum of student attitudes towards blended learning methods, incorporating both positively and negatively framed items to ensure a balanced representation of student perspectives. This comprehensive approach ensures that the developed scale robustly addresses the multifaceted nature of blended learning as outlined by the CoI framework, providing a powerful tool for assessing the efficacy of blended learning environments in supporting effective educational experiences for middle school students.

3.2.2. Expert Opinion and Item Refinement

The development of the attitude scale commenced with an extensive review by a panel of experts across fields such as science education, measurement and evaluation, and linguistics. This critical phase was designed to ensure the content validity of the initial 42-item draft, aligning each item with the specific requirements of assessing attitudes within blended learning contexts. Experts conducted a thorough analysis of each item, focusing on their relevance, clarity, and alignment with the overarching goals of the study. This rigorous review process led to the refinement of the scale by removing six items that were deemed redundant or not adequately aligned with the scale's objectives. The remaining 36 items were structured into a 5-point Likert scale, ranging from "strongly agree" to "strongly disagree," which is a widely recognized method for measuring attitudes. This format allows for a nuanced capture of responses, facilitating a detailed analysis of students' attitudes towards blended learning. This revised scale provides a robust tool for accurately gauging and interpreting diverse educational outcomes in blended learning settings.

3.2.3. Pre-Application and Scale Testing

Subsequently, the refined scale underwent a pre-application phase where it was administered to a select group of 14 middle school students. This phase was crucial for initial real-world testing of the scale's practical application, ensuring the items were understandable and relevant to the target demographic. The feedback received was instrumental in making final adjustments to the scale, optimizing it for broader application.

3.2.4. Comprehensive Application and Data Collection

The scale was then administered to a larger cohort of 267 students, ensuring comprehensive data collection from 259 participants. This phase was critical for assessing the scale's effectiveness in a real educational setting, emphasizing the importance of the study and engaging students to ensure sincere and thoughtful responses. Such extensive data collection not only reinforced the scale's practical utility but also its capacity to capture a wide array of attitudes towards blended learning.

3.2.5. Analysis of Data

The data analysis process was meticulously structured to assess and establish the construct validity of the newly developed attitude scale through Analysis . Factor analysis is a statistical method used to identify underlying relationships between measured variables (Kline, 2014). It reduces a large number of variables into fewer numbers of factors. Factors are essentially latent variables that represent clusters of related items within the dataset. These factors help in understanding the structure of the data and in identifying patterns that are not immediately apparent (Bartholomew et al., 2011).

Initially, the suitability of the data for factor analysis was confirmed by the Kaiser-Meyer-Olkin (KMO) measure, which yielded a coefficient suggesting excellent sampling adequacy, and Bartlett's Test of Sphericity, which indicated significant correlations among the items. This preliminary analysis set the stage for a more detailed exploration using Principal Component Analysis (PCA) with varimax rotation which is a statistical technique used to simplify the interpretation of factor analysis results by maximizing the variance of squared loadings of a factor across variables, making the structure clearer and more interpretable (Abdi, 2003). This step was crucial to discerning the underlying structures within the data, culminating in the identification of a robust two-factor structure that effectively delineated the diverse dimensions of students' attitudes towards blended learning. The factors extracted during this phase were rigorously validated to ensure their relevance and reliability. The internal consistency of each factor was quantitatively supported by high Cronbach's alpha values of .967 for the first factor and .923 for the second, indicating excellent reliability. These factors were further scrutinized through item test-total correlation and item discrimination analyses, which are pivotal in evaluating how well each item contributes to the overarching construct measured by the scale. The meticulous examination of these values not only reinforced the

scale's reliability but also its validity in capturing nuanced aspects of students' perceptions and attitudes. This comprehensive approach to data analysis ensured that the scale developed provides reliable, valid insights that are crucial for educators and researchers who aim to tailor and enhance blended learning strategies effectively. The integration of these rigorous analytical methods underscores the robustness of the scale, offering a dependable tool for assessing middle school students' attitudes towards blended learning and informing the development of more effective educational practices.

3.3. Compliance with Ethical Rules

Ethical principles and rules were followed at all stages of this research. Manisa Celal Bayar University Science Research Ethics Committee approved that the study was ethically convenient as of protocol Nr. 07/11/2018-E.95399. Aforementioned document related to ethics committee approval is presented in Appendix.

4. RESULTS

4.1. Item Analysis

The item analysis was conducted to ensure that each item on the scale effectively discriminates between respondents with high and low attitudes toward blended learning. This is crucial for validating the scale's effectiveness in capturing the nuanced perceptions of middle school students regarding blended learning. Following a method recommended by Tavşancıl (2006), we compared the average scores assigned to each item by the top 27% and the bottom 27% of respondents. Specifically, the highest scoring 70 students (approximately 27% of the 259 participants) were compared with the lowest scoring 70 students. This technique helps determine if the items are sensitive enough to capture variations in student attitudes, a pivotal aspect of the scale's utility. To achieve this, the independent groups t-test was used due to the statistical independence between the upper and lower scoring groups, allowing for a clear assessment of differences in responses. As shown in Table 2, all items on the scale exhibited significant levels of discrimination, indicating that they effectively distinguish between high and low scorers. This high level of item discrimination is essential for confirming the scale's reliability and validity, ensuring it accurately measures students' attitudes toward blended learning. By validating the effectiveness of each item, this analysis directly supports the first research question regarding the reliability of the newly developed attitude scale. The consistent high discrimination of items demonstrates the scale's capability to reliably differentiate between varying levels of student attitudes, ensuring robust measurement. The second research question, which concerns the scale's validity in representing attitudes toward blended learning, is addressed through the comprehensive item analysis combined with factor analysis. The significant discrimination levels observed for each item ensure that the scale accurately captures the intended constructs, providing a valid measure of students' attitudes toward blended learning.

TABLE 2. Results of item analysis regarding the blended learning methods

ITEM NUMBERS	Lower group		Upper group		t sub-upper (%27)
	M	SD	M	SD	
Item 1	3.558	.936	4.985	.121	12.456
Item 3	3.088	.973	4.970	.170	15.710
Item 4	2.647	1.075	4.926	.314	16.771
Item 6	1.176	.621	2.695	.944	11.107
Item 7	3.250	.853	4.970	.170	16.312
Item 8	3.470	1.071	4.941	.293	10.915
Item 10	3.044	.904	4.838	.535	14.069
Item 11	3.250	1.070	5.000	.000	13.483
Item 12	3.044	.921	4.970	.170	16.956
Item 15	2.882	.970	4.867	.341	15.918
Item 16	2.941	.861	4.897	.391	17.037
Item 20	2.867	1.063	4.911	.333	15.119
Item 22	3.088	.988	4.985	.121	15.707
Item 23	3.323	.761	4.926	.262	16.402
Item 25	2.794	1.030	4.926	.262	16.537
Item 26	2.764	.899	4.882	.406	17.689
Item 28	2.970	.913	4.985	.121	18.024
Item 29	2.926	.966	4.985	.121	17.423
Item 31	3.411	1.025	4.970	.170	12.365
Item 34	2.808	1.011	4.941	.293	16.700
Item 35	2.985	1.085	4.970	.170	14.896
Item 36	3.161	1.153	4.985	.121	12.959
Item 2	3.970	.845	4.705	.490	6.201
Item 5	2.205	.955	1.455	.656	5.337
Item 9	3.514	1.139	4.750	.436	8.349
Item 13	3.779	.990	4.794	.407	7.815
Item 14	3.779	.959	4.794	.407	8.027
Item 17	3.589	1.271	4.475	1.23	5.603
Item 18	3.948	.981	4.776	.674	6.272
Item 19	3.573	1.012	4.735	.613	8.094
Item 21	3.808	.950	4.661	.682	6.011
Item 24	3.691	.981	4.705	.520	7.535
Item 27	3.948	1.121	4.734	.608	7.624
Item 30	3.529	1.085	4.764	.427	8.732
Item 32	3.470	1.177	4.794	.407	8.758
Item 33	3.426	1.200	4.735	.613	8.003

M: Mean, SD: Standard Deviation, Significance Level: p<.05

4.2. Exploratory Factor Analysis (EFA)

EFA was utilized to reassess and refine the structure of our scale by examining the interrelationships among the scale items. To verify the appropriateness of conducting an EFA, the KMO measure and the Bartlett's Test of Sphericity were employed. These tests are crucial for assessing the adequacy of sample size and the suitability of the data for factor analysis. The KMO test, which measures sampling adequacy, returned a value of 0.943, suggesting an excellent fit for factor analysis as values closer to 1 indicate more suitable data for structure detection. Typically, a KMO value above 0.90 is considered excellent, while values below 0.50 are deemed unacceptable for a reliable factor analysis. Furthermore, the Bartlett's Test of Sphericity, which assesses the hypothesis that the variables are unrelated in the population, confirmed that the variables are sufficiently correlated for EFA. The significance of the chi-square statistic from this test was very high ($\chi 2$ = 1693.582, p<.000), strongly indicating that the data do not arise from a multivariate normal distribution where the variables are independent.

Upon confirming data suitability, principal components analysis was conducted, utilizing the varimax rotation. The rotation clarified the factor structure, enabling us to isolate and interpret the primary dimensions represented by the scale items. This methodological approach ensured that the derived factors were both statistically robust and meaningful, reflecting coherent underlying constructs that the scale aims to measure (see Table 3).

Following the execution of the factor analysis, two distinct factors emerged, each with eigenvalues exceeding 1. According to established analytical standards, the presence of factors that cumulatively explain at least two-thirds of the total variance in the data is indicative of their significance within the model. This threshold is crucial as it helps identify the most impactful factors that encapsulate the core dimensions being measured by the scale. The eigenvalues of these identified factors, alongside their respective contributions to the explained variance, effectively delineate the underlying constructs captured by the scale (see Table 4).

TABLE 3. KMO and BS tests towards blended learning methods attitude scale

KMO value	BS test values		
	χ2	df	p
.943	1693.582	593	.000*

Note. p< .000 (significance value), df: degree of freedom

TABLE 4. Characteristics of factors

Factor	Factor eigenvalues	Variance	Total variance
Factor 1	16.736	46.488%	57.035%
Factor 2	3.641	10.704%	

The strength of the factor structure of the scale is directly proportional to the size of the variance ratios derived from the analysis. A robust factor structure is indicated by higher variance ratios, which demonstrate that the factors identified capture a significant proportion of the total variance in the dataset. Generally, a variance ratio falling within the range of 40% to 60% is deemed sufficient. This range suggests that the factors adequately represent the underlying constructs without overfitting the data, thereby ensuring that the scale is both effective and efficient in measuring the intended attributes.

TABLE 5. Factor loadings of scale items

SCALE ITEMS	FACTOR LOADINGS	
	FACTOR 1	FACTOR 2
Item 1	0.759	
Item 3	0.818	
Item 4	0.785	
Item 6	0.762	
Item 7	0.789	
Item 8	0.602	
Item 10	0.629	
Item 11	0.759	
Item 12	0.807	
Item 15	0.723	
Item 16	0.782	
Item 20	0.773	
Item 22	0.701	
Item 23	0.701	
Item 25	0.825	
Item 26	0.789	
Item 28	0.856	
Item 29	0.847	
Item 31	0.647	
Item 34	0.746	
Item 35	0.776	
Item 36	0.790	
Item 2		0.563
Item 5		0.483
Item 9		0.785
Item 13		0.787
Item 14		0.740
Item 17		0.834
Item 18		0.748
Item 19		0.711
Item 21		0.664
Item 24		0.734
Item 27		0.855
Item 30		0.699
Item 32		0.808
Item 33		0.773

As detailed in Table 5, the scale comprises 36 items, with 22 categorized as positive and 14 as negative. The factors have been named according to the predominant sentiment of the items they include, which simplifies the interpretation and discussion of the scale's structure. Specifically, the first factor is labeled "Positive" and includes items 1, 3, 4, 6, 7, 8, 10, 11, 12, 15, 16, 20, 22, 23, 25, 26, 28, 29, 31, 34, 35, and 36. The second factor, labeled "Negative," encompasses items 2, 5, 9, 13, 14, 17, 18, 19, 21, 24, 27, 30, 32, and 33.

To further enhance the clarity and utility of the item categorization, the scale items have been grouped into three key dimensions: "Engagement," "Usefulness," and "Ease of Use." These dimensions were chosen to represent the primary areas of interest in evaluating students' attitudes towards blended learning. Engagement assesses how blended learning environments affect students' involvement and interaction in the learning process. Items in this category measure aspects such as student participation, motivation, and the extent to which blended learning fosters active learning. Positive engagement items include statements like "I greatly enjoy studying the lesson with the blended learning methods" and "My desire to learn increases in the lesson taught with the blended learning methods." Negative engagement items include statements like "I am afraid of failing the lesson taught with the blended learning methods" and "I find the teaching of the lesson with the blended learning methods boring." Usefulness evaluates the perceived benefits and effectiveness of blended learning methods in enhancing educational outcomes. This includes how well blended learning supports academic achievement, facilitates understanding of course material, and contributes to skill development. Positive usefulness items include statements like "I think the lesson taught with the blended learning methods is useful" and "I think that the information I learned in the lesson taught with the blended learning methods will last permanently." Negative usefulness items include statements like "I have difficulty in understanding the lesson taught with the blended learning methods" and "I do not think that the lesson taught with the blended learning methods is useful." Ease of Use captures students' perceptions of how user-friendly and accessible the blended learning tools and platforms are. Items in this category address the technological aspects, such as the ease of navigating online resources and the overall usability of the blended learning system. Positive ease of use items include statements like "I think that the lesson taught with the blended learning methods is understandable" and "Teaching the lesson with blended learning methods increases my motivation." Negative ease of use items include statements like "I find it difficult to follow the lesson taught with the blended learning methods" and "I find it difficult to communicate with my friends in the lesson taught with the blended learning methods."

The examination of factor loadings elucidates the variability in the correlation of scale items with the identified factors, providing a foundational assessment for optimizing blended learning strategies. Items with higher loadings, such as Item 28 (0.856) and Item 29 (0.847), demonstrate robust correlations with positive perceptions toward blended learning. This correlation aligns with educational frameworks like the Community of Inquiry, which emphasizes the importance of cognitive presence for meaningful learning experiences. Conversely, items exhibiting the lowest loadings, such as Item 5 (0.483) and Item 2 (0.563), may indicate aspects that are perceived as less central to, or less effectively captured within, student perceptions of blended learning. For instance, the lower loadings of items related to technical ease of use suggest that these elements, while important, may not directly impact students' overall attitudes as prominently as other dimensions. This variance underscores potential areas for refining the scale, particularly in terms of improving how these items are formulated or contextualized to better resonate with core educational

constructs. Statistically, the disparity in loadings, ranging from very high to moderately low, supports a robust factor structure of the scale, affirming its capacity to differentiate between the influential and less impactful aspects of blended learning experiences. This statistical validation is further enhanced by theoretical underpinnings, providing a nuanced understanding that not only corroborates the scale's construct but also aligns closely with blended learning theories that advocate for a balanced integration of online and face-to-face educational components.

4.3. Confirmatory Factor Analysis

The outcomes of Confirmatory Factor Analysis (CFA) provided a robust examination of the model's structure through the modification indices, which suggest possible adjustments for improving model fit. Additionally, the compatibility of the model with the empirical data was quantified through various fit indices detailed in Table 6.

TABLE 6. Findings related to CFA

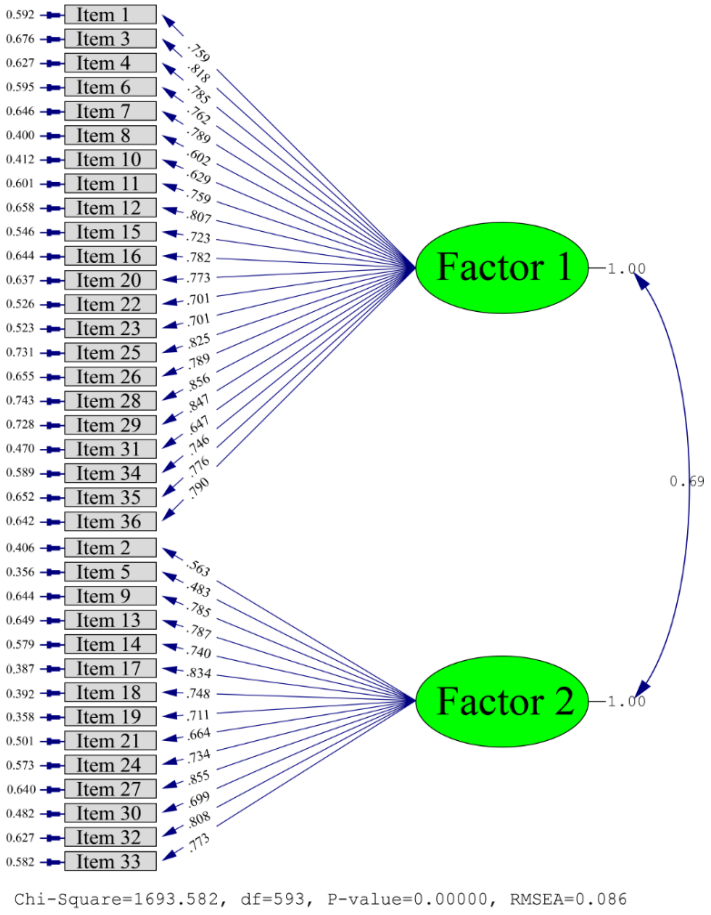
INDEX	PERFECT FIT CRITERIA	ACCEPTABLE FIT CRITERIA	RESEARCH FINDING	RESULT *
X^2/df	$0 \leq \chi^2/df \leq 3$	$3 \leq \chi^2/df \leq 5$	2.84	Perfect Fit
GFI	.95 ≤ GFI ≤ 1.00	.90 ≤ GFI ≤ .95	0.91	Acceptable Fit
CFI	.95 ≤ CFI ≤ 1.00	.90 ≤ CFI ≤ .95	0.93	Acceptable Fit
NFI	.95 ≤ NFI ≤ 1.00	.90 ≤ NFI ≤ .95	0.92	Acceptable Fit
AGFI	.90 ≤ AGFI ≤ 1.00	.85 ≤ AGFI ≤ .90	0.87	Acceptable Fit
RMSEA	.00 ≤ RMSEA ≤ .05	.05 ≤ RMSEA ≤ .10	0.086	Acceptable Fit
SRMR	.00 ≤ SRMR ≤ .05	.05 ≤ SRMR ≤ .08	0.076	Acceptable Fit

Note. *Baumgartner & Homburg (1996); Bentler (1980); Kline (2023); Hu & Bentler (1999)

In this study, a p-value of .000 ($p<.05$) indicated a significant difference between the expected and observed covariance matrices. The fit indices for the Confirmatory Factor Analysis (CFA) were evaluated to ensure the model's validity. The chi-square (χ^2) fit statistic showed a ratio of 2.84 to the degrees of freedom, indicating a perfect fit, as values below 3 and 5 suggest perfect and good fits, respectively (Kline, 2023). The Goodness of Fit Index (GFI) was 0.91, suggesting a perfect fit since values close to 1 indicate a good fit. The Comparative Fit Index (CFI) value of 0.93 indicated an acceptable fit, with values between 0.90-0.95 considered acceptable (Hu & Bentler, 1999; Tabachnick & Fidell, 2001). Similarly, the Normed Fit Index (NFI) was 0.92, which also signifies an acceptable fit, as values between 0.90-0.95 are acceptable (Kline, 2005). The Standardized Root Mean Square Residual (SRMR) value was 0.076, showing an acceptable fit as values close to 0 indicate a good fit. The Adjusted Goodness of Fit Index (AGFI) was 0.87, indicating an acceptable fit. Lastly, the Root Mean Square Error of Approximation (RMSEA) value was 0.086, demonstrating an acceptable fit, with values between 0.05 and 0.10 being acceptable (Hu & Bentler, 1995; Kline, 2014). These results confirm that the model fits the data well, with all indices within acceptable ranges.

The path diagram for the blended learning methods attitude scale in the CFA model is shown in Figure 3. This diagram illustrates the model's structure, including factor loadings and common factor variances for each item. The strong factor loadings indicate a robust goodness of fit, suggesting the items effectively measure the intended constructs. The diagram visually reinforces the analytical findings, providing a clear overview of the scale's structural validity and cohesive factor associations.

FIGURE 3. **Path diagram of the blended learning methods attitude scale for the CFA model**



4.4. Reliability Analysis

4.4.1. Internal consistency reliability-Cronbach's α coefficient

The resulting Cronbach's α values were analyzed for both the individual subscales and the entire scale. These values have been systematically tabulated and are detailed in Table 7. The presentation of these values allows for a nuanced understanding of the reliability of each component of the scale as well as the scale as a whole, highlighting the scale's overall ability to provide consistent and dependable results across various dimensions of the blended learning attitude construct.

TABLE 7. Reliability analysis results of blended learning methods attitude scale (Cronbach's α)

FACTOR	Items	Cronbach's α
Factor 1	1, 3, 4, 6, 7, 8, 10, 11, 12, 15, 16, 20, 22, 23, 25, 26, 28, 29, 31, 34, 35, 36	.967
Factor 2	2, 5, 9, 13, 14, 17, 18, 19, 21, 24, 27, 30, 32, 33	.923
Total		**.847**

A Cronbach's α value of 0.70 or higher is generally considered indicative of satisfactory reliability for scale scores, according to Cohen et al. (2007). Such a value confirms that the scale, along with its sub-dimensions, possesses robust internal reliability. This benchmark ensures that the items within the scale consistently measure the same underlying attributes, providing a reliable and stable gauge of the constructs intended to be assessed. When the Cronbach's α meets or exceeds this threshold, it signals that the scale is dependable for educational and psychological assessments, reflecting a high degree of internal consistency among the items.

4.4.2. Consistency of the scale using Pearson correlation coefficients (r)

The results indicated that these relationships were predominantly significant, with *p* values less than 0.05, suggesting a statistically significant correlation at a conventional level of confidence. These findings, detailed in Table 8, confirm that the scale items are not only closely related to their respective factors but also exhibit significant inter-correlations, reinforcing the scale's conceptual coherence and the interdependence of its various elements.

TABLE 8. Pearson correlation of the relationships between factors and scale scores

FACTORS	Pearson correlation coefficients (r)		
	FACTOR 1	FACTOR 2	TOTAL
Factor-1	1	-.603**	.868**
Factor-2	-.603**	1	-.132*
Total	**.868****	**-.132***	**1**

**Significance level: p<.01, *Significance level: p<.05

As detailed in Table 8, the correlation coefficient reveals a moderate negative consistency (r = -0.603) between the sub-factors, with statistical significance at the p < .01 level. This moderate negative correlation indicates that as scores on one factor increase, scores on the other factor tend to decrease, suggesting a divergent relationship between the constructs measured by these factors. Conversely, a high and positive correlation (r = .868) is observed between the first factor (Factor 1) and the overall scale score, also significant at the p < .01 level. This strong positive relationship indicates that higher scores on Factor 1 are closely associated with higher overall scores on the scale, affirming Factor 1's substantial influence on the scale's composite score. Additionally, a negative but low-level significant correlation (r = -0.132) exists between the second factor (Factor 2) and the total scale score, significant at the p < .05 level. This suggests that Factor 2 has a slight inverse relationship with the overall scale performance, though the impact is relatively minimal.

5. DISCUSSION

This research significantly enhances our understanding of the blended learning methods by showcasing the diverse impacts of blended learning environments on student attitudes. The newly developed scale not only corroborates but also expands upon previous theoretical assertions, such as those proposed by Lazar et al. (2020) and Tzafilkou et al. (2021). It does so by meticulously quantifying the influence of specific pedagogical approaches within blended learning on the attitudinal dimensions of middle school students. The results reveal that perceptions of blended learning are multifaceted and considerably varied, highlighting the coexistence of both positive and negative attitudes towards these learning environments. This complexity is crucial for extending theoretical frameworks and provides a nuanced view of how blended learning affects student engagement and learning outcomes (Bouilheres et al., 2020; Chiu, 2021; Fisher et al., 2021), suggesting that the educational impact of blended learning is not uniformly positive but rather dependent on a variety of interrelated factors.

Building on the nuanced understanding of student attitudes revealed in the previous analysis, these findings significantly inform the evolution of theoretical frameworks within the field of educational technology and pedagogy (Fawns, 2022). The discovery of a two-factor structure encompassing both positive and negative attitudes toward blended learning environments underscores the need for future theoretical models to incorporate these dual dimensions. By acknowledging the complexity of student attitudes, educators and researchers can better predict and enhance student outcomes (Cao, 2023; Yu et al., 2022). This understanding could facilitate the design of targeted interventions aimed at amplifying positive attitudes and alleviating negative ones (Olpak & Ateş, 2018). Such strategic interventions are pivotal for cultivating more effective and adaptive learning environments that respond dynamically to the varied needs and perceptions of students. This approach not only complements the findings that attitudes towards blended learning are varied and complex but also leverages this insight to propose practical solutions aimed at optimizing educational outcomes (Ateş & Garzon, 2022).

Furthermore, the findings of this study provide concrete insights into the design and implementation of blended learning environments. By identifying key factors that influence student attitudes towards blended learning, such as engagement levels and the effectiveness of digital tools, we can directly inform the instructional design processes. This approach ensures that blended learning techniques are not only aligned with educational outcomes but are also responsive to the diverse needs of students. The development of the attitude scale, validated through this research, enables educators to fine-tune these environments, ensuring they are conducive to learning and growth. Thus, by integrating our findings with existing blended learning strategies, we can enhance the practical application of these instructional methodologies, fostering environments that support both student engagement and academic success (Cigdem & Oncu, 2024).

Expanding on these practical insights, the research has incorporated specific attitudinal factors such as social interaction, technological ease of use, and pedagogical effectiveness into the attitude scale. This integration ensures that the scale accurately captures the essential elements that define the student experience in blended learning environments (Al-Maroof et al., 2022; Ohanu et al., 2023). These factors underscore the complexity of how students interact with and respond to blended environments, integrating both emotional

and cognitive responses with their social and technological contexts (Bizami et al., 2023). By exploring these deeper layers of influence, this study not only enhances our understanding of blended learning dynamics but also enriches the theoretical models used to interpret these phenomena. This refined understanding provides a foundation for designing more effective blended learning strategies that are comprehensively responsive to all dimensions of student experience, thus aligning closely with the practical applications discussed earlier and extending their impact on educational practice.

Building upon the concept of "attitudinal duality" and the complexities it introduces, the collective insights from this study enhance our understanding of the dynamic impacts of blended learning. They lay a robust foundation for refining educational theories to more accurately reflect the intricacies of contemporary educational environments. This research challenges the current theoretical landscape by illustrating that the true impact of blended learning is not singular, but rather multifaceted and influenced by a constellation of interrelated factors. These include the balance of pedagogical approaches, the integration of technology, and the psychological well-being of students. By acknowledging these diverse and interconnected elements, this study enriches existing theories, prompting a reevaluation of how blended learning environments are designed, implemented, and studied. This approach not only responds to the identified complexities but also suggests a pathway for future research and practice that is more aligned with the real-world experiences of learners in digitally enhanced educational settings.

6. CONCLUSIONS

This study has significantly enhanced our understanding of middle school students' attitudes towards blended learning by developing and validating a comprehensive attitude scale. The findings reveal the complexity of student perceptions, encompassing both positive and negative attitudes, and emphasize the need for educational strategies that address these diverse views. The research contributes to both theoretical and practical aspects of blended learning, offering detailed insights into how such educational methods impact student attitudes and suggesting ways to improve learning outcomes. The integration of educational psychology and instructional design principles provides a robust framework for future educational interventions and supports the ongoing evolution of blended learning practices. The study's implications for educational policy and practice are clear: tailored educational interventions must consider both the psychological and pedagogical aspects of student learning. This includes professional development for teachers, effective feedback mechanisms, and psychological support for students in navigating the challenges of blended learning environments.

6.1. Limitations and future lines of research

This study provides valuable insights into middle school students' attitudes towards blended learning, but it has certain limitations that future research should address. One major limitation is its reliance on a single educational context, which may not represent all middle school environments or student populations. Future studies should broaden the geographical scope and include diverse educational settings to see if findings are consistent across different cultures and systems. The study's cross-sectional design captures

attitudes at a specific point in time but does not account for how these attitudes might change as students and educational technologies evolve. Longitudinal studies could offer a more dynamic understanding of how attitudes towards blended learning develop over time, especially as students become more familiar with these practices. Potential bias in self-reported data is another limitation, as such data can sometimes reflect aspirational attitudes or be influenced by social desirability bias. Future research should use a mix of qualitative and quantitative methods, such as interviews or observations, to gain a deeper and more nuanced understanding of student attitudes and the factors influencing them. This study focused mainly on the cognitive and affective dimensions of student attitudes, without delving deeply into the behavioral aspect—how students actually engage with blended learning environments. Future research should explore this dimension to provide a comprehensive view of how attitudes align with actual behavior in blended learning contexts. Additionally, while the study identified key factors influencing student attitudes, it did not extensively examine the role of individual differences such as personal motivation, learning styles, and prior technological experience. These factors could significantly affect how students perceive and interact with blended learning environments. Future research should consider these personal attributes to tailor educational strategies that are not only effective but also personalized to meet the unique needs of each student.

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8. REFERENCES

Abdi, H. (2003). Factor rotations in factor analyses. In M. Lewis-Beck, A. Bryman, T. Futing. (Eds.), *Encyclopedia for Research Methods for the Social Sciences* (pp. 792-795). *Sage*.

Ateş, H. (2024). Designing a self-regulated flipped learning approach to promote students' science learning performance. *Educational Technology & Society, 27*(1), 65-83.

Akkoyunlu, B., & Yılmaz-Soylu, M. (2008). Development of a scale on learners' views on blended learning and its implementation process. *The Internet and Higher Education*, *11*(1), 26-32.

Akram, M., Iqbal, M. W., Ashraf, M. U., Arif, E., Alsubhi, K., & Aljahdali, H. M. (2023). Optimization of Interactive Videos Empowered the Experience of Learning Management System. *Computer Systems Science & Engineering*, *46*(1), 1021-1038. https://doi.org/10.32604/csse.2023.034085

Al-Maroof, R., Al-Qaysi, N., Salloum, S. A., & Al-Emran, M. (2022). Blended learning acceptance: A systematic review of information systems models. *Technology, Knowledge and Learning*, 1-36. https://doi.org/10.1007/s10758-021-09519-0

Armellini, A., Teixeira Antunes, V., & Howe, R. (2021). Student perspectives on learning experiences in a higher education active blended learning context. *TechTrends*, *65*(4), 433-443. https://doi.org/10.1007/s11528-021-00593-w

Ashraf, M. A., Yang, M., Zhang, Y., Denden, M., Tlili, A., Liu, J., Huang, R., & Burgos, D. (2021). A systematic review of systematic reviews on blended learning: trends, gaps and future directions. *Psychology Research and Behavior Management, 14,* 1525-1541. https://doi.org/10.2147/PRBM.S331741

Ateş, H., & Garzon, J. (2022). Drivers of teachers' intentions to use mobile applications to teach science. Education and Information Technologies, *27*(2), 2521-2542. https://doi.org/10.1007/s10639-021-10671-4

Ateş, H., & Garzon, J. (2023). An integrated model for examining teachers' intentions to use augmented reality in science courses. *Education and Information Technologies, 28*, 1299-1321. https://doi.org/10.1007/s10639-022-11239-6

Banihashem, S. K., Noroozi, O., den Brok, P., Biemans, H. J., & Kerman, N. T. (2023). Modeling teachers' and students' attitudes, emotions, and perceptions in blended education: Towards post-pandemic education. *The International Journal of Management Education*, *21*(2), 100803. https://doi.org/10.1016/j.ijme.2023.100803

Bartholomew, D. J., Knott, M., & Moustaki, I. (2011). *Latent variable models and factor analysis: A unified approach*. John Wiley & Sons.

Baumgartner, H., & Homburg, C. (1996). Applications of structural equation modeling in marketing and consumer research: A review. *International Journal of Research in Marketing, 13*(2), 139-161. https://doi.org/10.1016/0167-8116(95)00038-0

Bentler, P.M. (1980). Multivariate analysis with latent variables: *Causal modeling. Annual Review of Psychology, 31* (1), 419-456. https://doi.org/10.1146/annurev.ps.31.020180.002223

Bervell, B., Umar, I. N., Kumar, J. A., Asante Somuah, B., & Arkorful, V. (2021). Blended learning acceptance scale (BLAS) in distance higher education: toward an initial development and validation. *Sage Open*, *11*(3), 21582440211040073. https://doi.org/10.1177/21582440211040073

Bhagat, K. K., Cheng, C. H., Koneru, I., Fook, F. S., & Chang, C. Y. (2023). Students' blended learning course experience scale (BLCES): Development and validation. *Interactive Learning Environments*, *31*(6), 3971-3981. https://doi.org/10.1080/10494820.2021.1946566

Bizami, N. A., Tasir, Z., & Kew, S. N. (2023). Innovative pedagogical principles and technological tools capabilities for immersive blended learning: a systematic literature review. *Education and Information Technologies*, *28*(2), 1373-1425. https://doi.org/10.1007/s10639-022-11243-w

Blau, I., & Hameiri, M. (2017). Ubiquitous mobile educational data management by teachers, students and parents: Does technology change school-family communication and parental involvement?. *Education and Information Technologies*, *22*, 1231-1247. https://doi.org/10.1007/s10639-016-9487-8

Bouilheres, F., Le, L. T. V. H., McDonald, S., Nkhoma, C., & Jandug-Montera, L. (2020). Defining student learning experience through blended learning. *Education and Information Technologies*, *25*(4), 3049-3069. https://doi.org/10.1007/s10639-020-10100-y

Cao, W. (2023). A meta-analysis of effects of blended learning on performance, attitude, achievement, and engagement across different countries. *Frontiers in psychology*, *14*, 1212056. https://doi.org/10.3389/fpsyg.2023.1212056

Chaw, L. Y., & Tang, C. M. (2023). Exploring the role of learner characteristics in learners' learning environment preferences. *International Journal of Educational Management*, *37*(1), 37-54. https://doi.org/10.1108/IJEM-05-2022-0205

Chiu, T. K. (2021). Digital support for student engagement in blended learning based on self-determination theory. *Computers in Human Behavior*, *124*, 106909. https://doi.org/10.1016/j.chb.2021.106909

Cigdem, H., & Oncu, S. (2024). Understanding the Role of Self-Regulated Learning in academic success: a blended learning perspective in vocational education. *Innoeduca: International Journal of Technology and Educational Innovation*, *10*(1), 45-64. https://doi.org/10.24310/ijtei.101.2024.17432

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. New York: Routledge.

Çemçem, G. D., Korkmaz, Ö., & Kukul, V. (2024). Readiness of teachers for blended learning: A scale development study. *Education and Information Technologies*, 1-25. https://doi.org/10.1007/s10639-024-12777-x

Çobanoğlu, N., & Demir S. (2023). Investigation of preschool the approaches of teachers towards inclusion, inclusion competencies and classroom management skills. *International Online Journal of Education and Teaching (IOJET), 10*(3), 1868-1885.

Dakhi, O., Jama, J., & Irfan, D. (2020). Blended learning: a 21st century learning model at college. *International Journal of Multi Science*, *1*(08), 50-65.

Dangwal, K. L. (2017). Blended learning: An innovative approach. *Universal Journal of Educational Research*, *5*(1), 129-136. https://doi.org/10.13189/ujer.2017.050116

ElSayary, A. (2023). The impact of a professional upskilling training programme on developing teachers' digital compe-

tence. *Journal of Computer Assisted Learning*, *39*(4), 1154-1166. https://doi.org/10.1111/jcal.12788

Fawns, T. (2022). An entangled pedagogy: Looking beyond the pedagogy—technology dichotomy. *Postdigital Science and Education*, *4*(3), 711-728. https://doi.org/10.1007/s42438-022-00302-7

Fisher, R., Perényi, A., & Birdthistle, N. (2021). The positive relationship between flipped and blended learning and student engagement, performance and satisfaction. *Active Learning in Higher Education*, *22*(2), 97-113. https://doi.org/10.1177/1469787418801702

Han, F., & Ellis, R. A. (2020). Initial development and validation of the perceptions of the blended learning environment questionnaire. *Journal of Psychoeducational Assessment*, *38*(2), 168-181. https://doi.org/10.1177/0734282919834091

Hu, L.T., & Bentler, P. M. (1995). Evaluating model fit. In: RH. Hoyle (Ed.), *Structural Equation Modeling: Concepts, Issues, and Applications* (pp. 76-99). Sage.

Hu, L.T., Bentler, P. M., (1999). Cutoff Criteria for Fit Indexes in Covariance Structure Analysis: Conventional Criteria versus New Alternatives. Structural Equation Modeling, 6(1), 1-55. https://doi.org/10.1080/10705519909540118

Khlaif, Z. N., Sanmugam, M., Joma, A. I., Odeh, A., & Barham, K. (2023). Factors influencing teacher's technostress experienced in using emerging technology: A qualitative study. *Technology, Knowledge and Learning*, *28*(2), 865-899. https://doi.org/10.1007/s10758-022-09607-9

Kikalishvili, S. (2023). Unlocking the potential of GPT-3 in education: Opportunities, limitations, and recommendations for effective integration. *Interactive Learning Environments*, 1-13. https://doi.org/10.1080/10494820.2023.2220401

Kilag, O. K., Obaner, E., Vidal, E., Castañares, J., Dumdum, J. N., & Hermosa, T. J. (2023). Optimizing Education: Building Blended Learning Curricula with LMS. *Excellencia: International Multi-disciplinary Journal of Education (2994-9521)*, *1*(4), 238-250.

Kline, P. (2014). *An easy guide to factor analysis*. Routledge.

Kline, R. B. (2023). *Principles and practice of structural equation modeling* (15th edition). Guilford Press

Kline, T. (2005). *Psychological testing: A practical approach to design and evaluation*. Sage.

Lazar, I. M., Panisoara, G., & Panisoara, I. O. (2020). Digital technology adoption scale in the blended learning context in higher education: Development, validation and testing of a specific tool. *PloS one*, *15*(7), e0235957. https://doi.org/10.1371/journal.pone.0235957

López-Pellisa, T., Rotger, N., & Rodríguez-Gallego, F. (2021). Collaborative writing at work: Peer feedback in a blended learning environment. *Education and Information Technologies, 26*(1), 1293-1310. https://doi.org/10.1007/s10639-020-10312-2

Niu, Y., Xi, H., Liu, J., Sui, X., Li, F., Xu, H., ... & Guo, L. (2023). Effects of blended learning on undergraduate nursing students' knowledge, skill, critical thinking ability and mental health: a systematic review and meta-analysis. *Nurse Education in Practice*, 103786. https://doi.org/10.1016/j.nepr.2023.103786

Ohanu, I. B., Shodipe, T. O., Ohanu, C. M., & Anene-Okeakwa, J. E. (2023). System quality, technology acceptance model and theory of planned behaviour models: Agents for adopting blended learning tools. *E-Learning and Digital Media*, *20*(3), 255-281. https://doi.org/10.1177/20427530221108031

Olpak, Y. Z., & Ateş, H. (2018). Pre-Service science teachers' perceptions toward additional instructional strategies in biology laboratory applications: Blended learning. *Science Education International, 29*(2), 88-95. https://doi.org/10.33828/sei.v29.i2.3

Peng, Y., Wang, Y., & Hu, J. (2023). Examining ICT attitudes, use and support in blended learning settings for students' reading performance: Approaches of artificial intelligence and multilevel model. *Computers & Education*, *203*, 104846. https://doi.org/10.1016/j.compedu.2023.104846

Singh, J., Steele, K., & Singh, L. (2021). Combining the best of online and face-to-face learning: Hybrid and blended learning approach for COVID-19, post vaccine, & post-pandemic world. *Journal of Educational Technology Systems*, *50*(2), 140-171. https://doi.org/10.1177/00472395211047865

Smith, K., & Hill, J. (2018). Defining the nature of blended learning through its depiction in current research. *Higher Education Research and Development, 38*(2), 383-397. https://doi.org/10.1080/07294360.2018.1517732

Stec, M., Smith, C., & Jacox, E. (2020). Technology enhanced teaching and learning: Exploration of faculty adaptation to iPad delivered curriculum. *Technology, Knowledge and Learning*, *25*(3), 651-665. https://doi.org/10.1007/s10758-019-09401-0

Tabachnick, B. G., & Fidell, L. S. (2001). *Using Multivariate Statistics* (4th edition). MA: Allyn & Bacon, Inc.

Tavşancıl, E. (2006). *Measurement of attitudes and data analysis with SPSS* (3rd edition). Nobel Publishing.

Tzafilkou, K., Perifanou, M., & Economides, A. A. (2021). Development and validation of a students' remote learning attitude scale (RLAS) in higher education. *Education and Information Technologies*, *26*(6), 7279-7305. https://doi.org/10.1007/s10639-021-10586-0

Weng, C. H., & Tang, Y. (2014). The relationship between technology leadership strategies and effectiveness of school administration: An empirical study. *Computers & Education*, *76*, 91-107. https://doi.org/10.1016/j.compedu.2014.03.010

Yu, Z., Xu, W., & Sukjairungwattana, P. (2022). Meta-analyses of differences in blended and traditional learning outcomes and students' attitudes. *Frontiers in psychology*, *13*, 926947. https://doi.org/10.3389/fpsyg.2022.926947

Zhang, Z., Cao, T., Shu, J., & Liu, H. (2020). Identifying key factors affecting college students' adoption of the e-learning system in mandatory blended learning environments. *Interactive Learning Environments*, *30*(8), 1388-1401. https://doi.org/10.1080/10494820.2020.1723113

APPENDIX: The developed scale

Item No	STATEMENTS	Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	I think the lesson taught with the blended learning methods is useful.					
2	I have difficulty in understanding the lesson taught with the blended learning methods.					
3	I greatly enjoy studying the lesson with the blended learning methods.					
4	I can not wait to go to the lesson taught with the blended learning methods.					
5	I am afraid of failing the lesson taught with the blended learning methods.					
6	Teaching the lesson with the blended learning methods allows me to learn faster.					
7	I think that the lesson taught with the blended learning methods is understandable.					
8	I think the lesson taught with the blended learning methods is fun.					
9	I find the teaching of the lesson with the blended learning methods boring.					
10	I like to share the information I learned in the lesson taught with the blended learning methods with others.					
11	I like the lesson taught with the blended learning methods.					
12	My desire to learn increases in the lesson taught with the blended learning methods.					
13	I get restless when the lesson taught with the blended learning methods.					
14	Teaching the lesson with the blended learning methods reduces my interest in the lesson.					
15	I do not notice time passing in the lesson taught with the blended learning methods.					
16	Teaching the lesson with blended learning methods encourages me to do research.					
17	I do not think that the blended learning methods is suitable for other lessons.					

Item No	STATEMENTS	Strongly agree	Agree	Undecided	Disagree	Strongly disa-
18	I find it difficult to communicate with my friends in the lesson taught with the blended learning methods.					
19	I do not like that the lesson is taught by BL.					
20	The lesson taught with the blended learning methods allows me to demonstrate my own ability.					
21	I am irritated that the lesson is taught with the blended learning methods.					
22	I think I got the best out of the lesson taught with the blended learning methods.					
23	I think that the information I learned in the lesson taught with the blended learning methods will last permanently.					
24	I find it difficult to follow the lesson taught with the blended learning methods.					
25	Teaching the lesson with blended learning methods increases my creativity.					
26	My self-confidence increases in the lesson taught with the blended learning methods.					
27	I am afraid of making mistakes in the lesson taught with the blended learning methods.					
28	Teaching the lesson with blended learning methods increases my motivation.					
29	My interest increases in the lesson taught with the blended learning methods.					
30	I am not motivated in the lesson taught with the blended learning methods.					
31	I think I will be successful in the lesson taught with the blended learning methods.					
32	I do not think that the lesson taught with the blended learning methods is useful.					
33	I think that the lesson taught with the blended learning methods is a waste of time.					
34	I think that the lesson taught with the blended learning methods helped me develop socially.					
35	I think I will get better grades in the lesson taught with the blended learning methods.					
36	The lesson taught with the blended learning methods increases my curiosity.					

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Evaluation of a scale on ICT knowledge applied to educational inclusion: A Graded Response Model approach

Evaluación de una escala sobre conocimiento de las TIC aplicadas a la inclusión educativa: Un enfoque desde el Modelo de Respuesta Graduada

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ABSTRACT

The rapid advance of Information and Communication Technologies (ICT) represents a crucial challenge and opportunity for contemporary society. These tools have not only transformed the way people communicate and work, but have also redefined pedagogical paradigms, posing new demands and possibilities for education systems. The incorporation of these resources in the classroom promotes educational equity and quality, preparing students with functional diversity for an increasingly digitalized world and favoring accessible, innovative and inclusive teaching-learning processes. The aim of this study is to evaluate a scale to measure prospective teachers knowledge of ICT applied to educational inclusion using the Graduated Response Model (GRM). A psychometric study was carried out on a non-probabilistic sample of 684 university students of the Degree in Primary Education from different andalusian public universities, using a reduced version of the Knowledge Scale of ICT applied to people with disabilities by Cabero-Almenara et al. (2016). The data reflect significant diversity in participants knowledge of ICT applied to people with disabilities. In addition, the accuracy in estimating latent scores supports the validity of the measurement instrument. The results indicate that the scale used is not only effective in measuring the average knowledge of the participants, but it is also capable of detecting significant variations among individuals. Therefore, it is concluded that this scale is a useful predictive tool for identifying training deficiencies and designing training programs that respond to these needs.

KEYWORDS GRM; diagnostic instrument; ICT; inclusion; initial teacher training.

RESUMEN

El rápido avance de las Tecnologías de la Información y la Comunicación (TIC) representa un desafío y una oportunidad crucial para la sociedad contemporánea. Estas herramientas no solo han transformado la manera en que las personas se comunican y trabajan, sino que también han redefinido los paradigmas pedagógicos, planteando nuevas exigencias y posibilidades para los sistemas de enseñanza. La incorporación de estos recursos en las aulas promueve la equidad y calidad educativa, preparando a los estudiantes con diversidad funcional para un mundo cada vez más digitalizado y favoreciendo procesos de enseñanza-aprendizaje accesibles, innovadores e inclusivos. El objetivo de este estudio es evaluar una escala para medir el conocimiento de los futuros docentes sobre las TIC aplicadas a la inclusión educativa mediante el Modelo de Respuesta Graduada (MRG). Se ha llevado a cabo un estudio psicométrico sobre una muestra no probabilística de 684 estudiantes universitarios del Grado en Educación Primaria de diferentes universidades públicas andaluzas, utilizando una versión reducida de la Escala de Conocimiento de las TIC aplicadas a las personas con diversidad funcional de Cabero-Almenara et al. (2016). Los datos reflejan una diversidad significativa en el conocimiento de los participantes sobre las TIC aplicadas a personas con diversidad funcional. Además, la precisión en la estimación de las puntuaciones latentes respalda la validez del instrumento de medición. Los resultados indican que la escala empleada no solo es efectiva para medir el conocimiento promedio de los participantes, sino que también es capaz de detectar variaciones significativas entre individuos. Por tanto, se concluye que esta escala es una herramienta predictiva útil para identificar deficiencias formativas y diseñar planes de estudios que respondan a estas necesidades.

PALABRAS CLAVE MRG; escala de medición; TIC; inclusión; formación inicial docente.

1. INTRODUCTION

The need to adapt to a constantly changing world, where Information and Communication Technologies (ICT) have a prominent relevance, is presented as one of the main goals of today's society. Educational digital tools can be configured to provide learning resources at different levels of difficulty and in various formats (audio, text, video, etc.), so as to ensure the principles of accessibility and adaptability so that each student can access the content in a way that is understandable and manageable, following the Universal Design for Learning approach (Parody-García et al., 2022; Vigo, 2021). In addition, technology plays a fundamental role in the development of digital and communication skills for students with functional diversity, while favoring their autonomy, motivation, academic performance and integral development.

The integration of ICT in education has meant the reformulation of teaching approaches, establishing the updating of teaching and the modification of the curricula of future teachers as elementary factors to ensure that technologies have a positive impact on the teaching-learning processes of all learners, including students with functional diversity (Moriña, 2020; Parra & Agudelo, 2020; Vigo, 2021). In this context, the United Nations Educational, Scientific and Cultural Organization [UNESCO] (2019) has presented a reference framework for teacher professional development with digital competences standards that allow countries to offer a comprehensive view of ICT in education, addressing them from six dimensions (understanding the role of ICT in education policy, curriculum and assessment, pedagogy, digital competences, organization and management, and teacher professional learning) in three progressive stages (knowledge acquisition, knowledge deepening and knowledge creation). These competences can be described as the combination of knowledge, skills and attitudes towards technologies that teachers must acquire and put into practice in

order to optimize their professional work from a critical, creative, innovative and inclusive paradigm (National Institute of Educational Technologies and Teacher Training [INTEF], 2022).

The development of technological skills in teachers should be promoted from their initial training, considering that this training should focus on an epistemological, theoretical and practical foundation that also contemplates the acquisition of attitudinal and procedural competences focused on achieving quality inclusive education (Kerexeta-Brazal et al., 2022; Recio-Muñoz et al., 2020; Ripoll-Rivaldo, 2021). These competences, according to Almerich et al. (2020), are classified into technological competences, referring to the skills that enable the mastery of digital tools; pedagogical competences, which are related to the use of technological resources to carry out training or academic tasks; and ethical competences, linked to the appropriate use of ICT.

The process of pedagogical innovation must transcend from the promotion of basic digital skills to the development of specific technological competences that favor the creation of optimal learning environments adapted to the needs, characteristics and interests of all students. Along these lines, Cabero-Almenara and Martínez (2019) point out that ICT training is gradual and takes time to consolidate the knowledge and skills needed to carry out innovative educational practices.

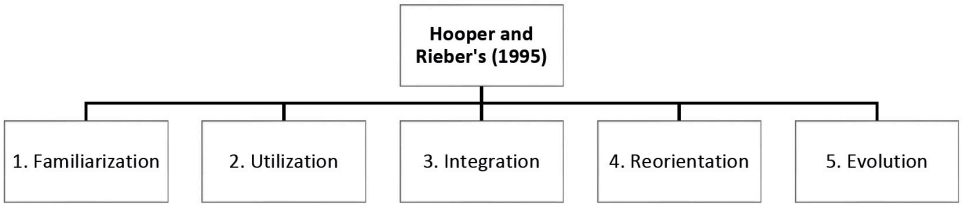
Tejedor et al. (2009) argue that teachers can show different attitudes towards the use of ICT: interest in technology (technophilia) or, on the contrary, rejection of its use (technophobia). Hence the importance of making teachers aware of the importance of using ICT for didactic and inclusive purposes from their initial training.

Several studies related to the integration of ICT in initial teacher education examine how content and training in digital competence are being addressed, share enriching experiences for the transformation of training practices and reflect on key changes to improve teacher education (Ari et al., 2022; Pinto-Santos et al., 2023).

Following an extensive review of the literature, a number of models on the development of teachers' digital competences have been analyzed which emphasize that it is a progressive and multifaceted process. The most prominent of these are:

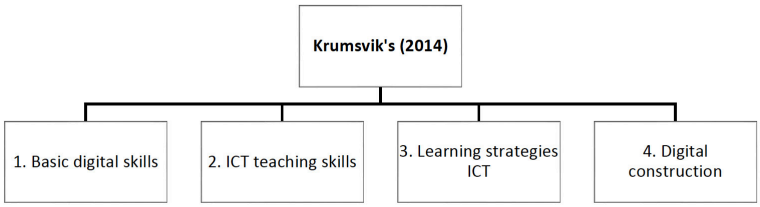
- Hooper and Rieber's (1995) model: it envisages five phases in the process (familiarization as the initial stage of learning ICT outside the classroom, incorporation of what has been learned into the school context, integration as decision-making for technology-mediated activities, reconsideration of teaching praxis in terms of ICT possibilities and students' needs/characteristics and, finally, continuous familiarization, which is based on the recognition that there are always new ICT solutions and the adoption of new decisions).

DIAGRAM 1. Hooper and Rieber's model (1995)



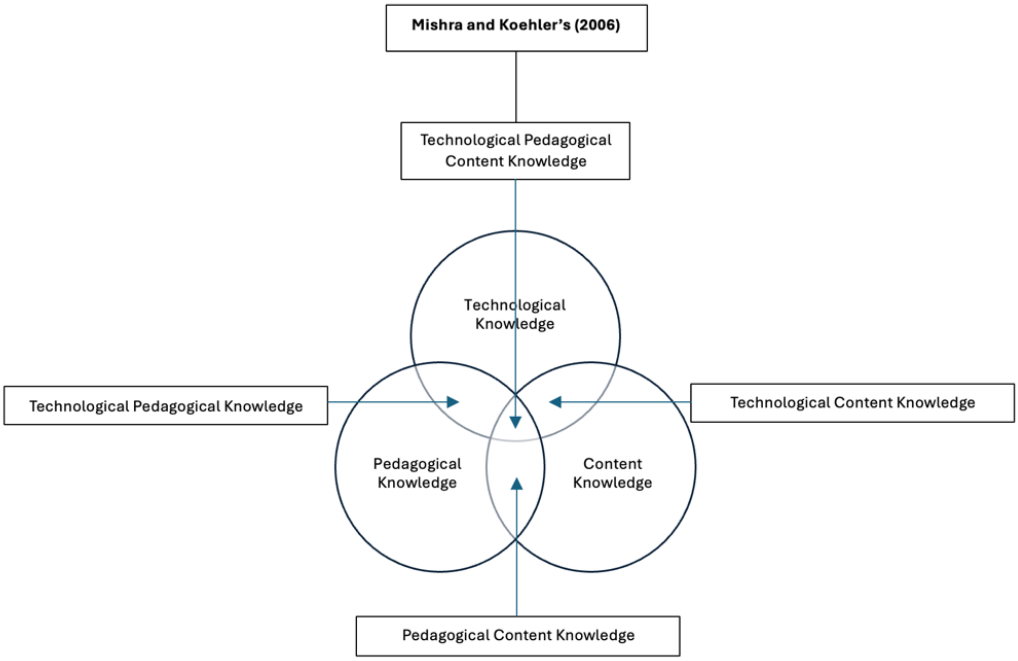
- Krumsvik's model (2014): determines four stages to achieve optimal digital competence (basic digital skills, ICT teaching skills, learning strategies ICT and digital construction).

DIAGRAM 2. Krumsvik's model (2014)



- Mishra and Koehler's model (2006): this is a model that has gained some traction in recent years, known as Technological Pedagogical Content Knowledge (TPACK). It is based on the acquisition of three types of basic knowledge (technological, pedagogical and content knowledge). This approach argues that such knowledge should be acquired in combination (pedagogical content knowledge, knowledge of the use of technologies, technological pedagogical knowledge, and technological, pedagogical and content knowledge).

DIAGRAM 3. Mishra and Koehler's model (2006)



Taking the aforementioned models as a reference, Cabero-Almenara and Martínez (2019) mention the following aspects to bear in mind in ICT teacher training: training actions should not be limited to traditional approaches or focus solely on technological aspects, so they should be approached from different and transversal perspectives to be more effective; training should consider various dimensions (instrumental, semiological/aesthetic, curricular, pragmatic, psychological, producer/designer, selector/evaluator, critic, organizer, attitudinal, and researcher) and reflection on professional performance should be encouraged.

The teacher training framework should therefore include a series of competences that can be summarized as follows: a predisposition towards cooperative work and curricular flexibility, technical and didactic management of ICT, attention to diversity, organizational skills and the ability to adapt to change (Almerich et al., 2020; Kerexeta-Brazal et al., 2022; Laitón et al., 2017). While it is true that teacher training in the knowledge and appropriate use of ICT is essential, the importance of the provision of technological resources by educational institutions in order to offer innovative and inclusive education should not be overlooked (Gallardo-Montes et al., 2023; Pegalajar, 2017).

The aim of this study is to evaluate an instrument (scale) to measure prospective teachers' knowledge of ICT applied to educational inclusion using the Graded Response Model (GRM). More specifically, we set out the following specific objectives: O1) to evaluate the psychometric properties of the scale; and O2) to determine the effectiveness of the items in discriminating between different levels of knowledge.

This study is part of a larger research project analyzing teacher training in the development of digital competences applied to inclusive education (Parody-García, in press).

2. MATERIAL AND METHOD

A research process has been carried out, sometimes considered within analytical designs (Colás-Bravo & Buendía-Eisman, 1998) although it undoubtedly corresponds to a psychometric study (Romero-Martínez & Ordóñez-Camacho, 2015) on a non-probabilistic sample of 684 university students of the Degree in Primary Education from different Andalusian public universities (UMA, UGR, UAL, UJA, UCA, UCO, US, UHU). Table 1 shows the socio-demographic characteristics of the sample.

TABLE 1. Sample characteristics

Age:	**media=20.39 (D.T.=4.285).**
Sex:	Male: 176
	Female: 508
University of origin:	U. Granada: 161
	U. Málaga: 476
	Other Andalusian universities: 47

Acronyms: U.= University; T.D. = Standard Deviation

Data collection was carried out during the 2022-2023 academic year, specifically during the months of January to June 2023. To this end, university teachers from different Andalusian public universities who teach different courses and groups of the Primary Education Degree were contacted by e-mail. A letter of introduction was sent to them detailing the purpose of the study and requesting their collaboration in order to distribute the questionnaire among their students (in the case of the University of Malaga, we attended the classes of the lecturers who showed their interest in the study and allowed them to spend some time in their session for the dissemination and completion of the questionnaire by the students). It should be noted that in the same link as the questionnaire, the informed consent document was attached, in which the ethical principles and confidentiality of the research, as well as the rights of the participants, are included.

The instrument used was a reduced version of the ICT Knowledge Scale applied to people with functional diversity by Cabero-Almenara et al. (2016), the purpose of which was to find out the level of training and

knowledge of students studying for a Primary Education Degree in Spain on this subject. Specifically, it was applied to a non-probabilistic sample of 533 university students from several Spanish universities (Universities of the Basque Country, Cantabria, Cordoba, Huelva, Alicante, Murcia, Malaga, Balearic Islands, Santiago de Compostela, Jaen and Seville). The authors elaborated a Likert-type scale of 73 items, of which 18 refer to the technical-didactic mastery of different technologies and 55 are based on the assessment of the use of ICT for people with functional diversity. In this article, we focus on the 12 general items of the latter group (see table 2).

The results of the study of these authors obtained a Cronbach's alpha of 0.992 points and identified 6 subscales that would explain 78.073% of the variance: general scale, visual scale, auditory scale, cognitive scale, motor scale and accessibility scale. These values can be consulted in the articles published by the authors (Cabero-Almenara et al. 2016) where they explain in detail the construction and validation process, including the goodness-of-fit indices of the models (e.g. KMO and similar) as well as the different analytical procedures from the Classical Test Theory (CTT).

Only the general scale has been used for this study as: a) it includes substantially fewer items, b) it provides a general measure of knowledge allowing it to be used as a screening test for an initial assessment, and c) the scale items are considered to be unidimensional (see table 2).

TABLE 2. General scale items

- V15: I have general knowledge about the possibilities that ICTs offer to people with disabilities.
- V16: I can select specific ICTs according to the physical, sensory and cognitive characteristics of different people.
- V17: I am able to provide information on the possibilities of ICT for the labor market integration of people with different types of disabilities.
- V18: I am aware of different books that are specifically dedicated to the analysis of the possibilities of ICTs for people with different types of disabilities.
- V19: I am aware of different educational experiences of applying ICT for people with different types of disabilities.
- V20: I am familiar with mobile applications in relation to subjects with special educational needs.
- V21: I am aware of the main limitations that may condition the use of ICT by learners with disabilities.
- V22: I know different places on the Internet where I can find educational materials for people with special educational needs.
- V23: In general, I feel prepared to help the student with certain disabilities in the use of technical aids and the use of ICT.
- V24: I can design activities with generalized educational software for learners with special educational needs.
- V76: I am aware of the problems and the importance of different types of disabilities for the use of ICT.
- V77: I consider myself competent in locating educational materials for learners with specific educational support needs on the web.

To achieve the proposed objectives, a psychometric analysis was carried out from the perspective of Item Response Theory or IRT (Baker & Kim, 2004; Van der Linden & Hambleton, 1997). This approach encompasses a series of models designed to explain the connection between an unobservable skill, trait or competence such as domain knowledge and its observable indicators, the responses given to a set of items.

Unlike TCT, which focuses on composite scores and linear regression, IRT focuses on response patterns and considers them in probabilistic terms. This approach takes into account:

- Item discrimination: the ability of an item to distinguish between individuals with different levels of knowledge.
- Item difficulty: the level of knowledge at which 50% of respondents are expected to answer an item correctly, indicating the probability of a correct response.
- Additional parameters: depending on the specific IRT model, parameters such as guessing probability may also be considered.

Assessing item difficulties is crucial to align the test with the knowledge levels of the target population and to ensure full coverage of the knowledge range. Therefore, IRT models offer several advantages over TCT models, such as allowing the construction of scales that differentiate optimally between high and low cognitive individuals, while allowing scales to have fewer items than other psychometric approaches. Thus, although IRT was developed on tests of dichotomous items, a generalization of the procedure for polytomous items is available as the Graded Response Model (GRM), which was developed by Samejima (1969). Specifically, the following analyses have been carried out in this study using this GRM approach:

- Analysis of the unidimensionality of the scale: this is a preliminary step in the application of IRT models. This can be done in many different ways: exploratory factor analysis, principal component analysis, correspondence analysis, or even simply inter-item correlation (Rizopoulos, 2006). Among the different ways of analyzing unidimensionality, Principal Component Analysis was chosen (Chou & Wang, 2010; Wismeijer et al., 2008). For the assessment of model fit, the Root Mean Square of Residuals (RMSR) was taken into account, which always gives, whatever the estimated model and solution, a reference value of 0.05 (Harman, 1976); the Tucker-Lewis Index (TLI), where values above 0.95 indicate a good fit (Bentler, 1990); and the root mean square error of approximation (RMSEA), where values less than 0.05 indicate a good model fit and values up to 0.08 represent a reasonable error of approximation to the population (Browne & Cudeck, 1993). For a detailed discussion of these issues, see Ferrando et al. (2022). These values should be interpreted in context with the nature of the data, being considered as a whole and in relation to the construct or theoretical model (Lorenzo-Seva et al., 2011). In this way, the cut-off points established by the authors are benchmarks that provide guidance on goodness of fit and are interpreted flexibly (Lai & Green, 2016).
- Parameter estimation for each item: discrimination and difficulty parameters were estimated for each item, including response thresholds to determine the corresponding proficiency levels.
- Assessment of model goodness-of-fit: model fit was verified using indices such as log-likelihood, Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), ensuring model fit to the data.
- Information function analysis: the information function of the test was analyzed to assess the precision of the estimates along the latent trait continuum, identifying the areas of highest precision.
- Review of bivariate margin calls: bivariate margin calls were reviewed to identify problems of fit between pairs of items, highlighting those with a significant lack of fit.

It should be noted that the *ltm* package (Rizopoulos, 2006) implemented in R (R Core Team, 2022) was used for the entire analysis.

3. RESULTS

In the following sub-sections, the results are organised on the basis of the objectives defined in this study.

3.1. To assess the psychometric properties of the scale

As noted above, a preliminary step in applying IRT is the verification of the assumption of unidimensionality. On this occasion, this phase was started with a principal component analysis (PCA) followed by an exploratory factor analysis (EFA). The suitability of the data set for these procedures was assessed by means of the Kaiser-Meyer-Olkin KMO test (which was 0.94) and Bartlett's test of sphericity (which was statistically significant X^2=5249.695 with 66 degrees of freedom, being p<.001), thus supporting the application of these analyses. In this study, with the sample under analysis, the PCA results show that the first principal component (PC1) explains 57% of the total variance of the items. The items have standard loadings on the first component ranging from 0.58 to 0.83, suggesting a good contribution of most of the items to the unidimensional factor. The root mean square root of residuals (RMSR) value was 0.08, with a chi-square of 517.92 and a probability p <.001, indicating that a one-component model provides a basic, but reasonably adequate.

To complement the PCA, an exploratory factor analysis (EFA) was conducted using the least squares method. The results of the EFA indicate that the first factor explains 53% of the total variance, with a sum of squared loadings of 6.41. The factor loadings of the items in the first factor vary between 0.54 and 0.82, which confirms a good contribution of the items to the unidimensional factor. On the other hand, the RMSR was 0.06, with an empirical chi-square of 380.16 and a probability p < .001, while the Tucker Lewis fit index (TLI) was 0.853 and the RMSEA index was 0.13, with 90% confidence intervals between 0.121 and 0.139. These results suggest that the fit is mediocre, however, it is assumed to be useful to the extent that: the 2-component model presented a worse fit, the deviations from the optimal cut-off points are not extreme, and furthermore, the model is consistent with the theoretical validity of the original instrument.

3.2. Determine the effectiveness of the items in discriminating between different levels of knowledge

In addition, a categorical principal components analysis (Princals) was performed to examine the structure of the items. The results show that the first eigenvalue is 6.91, confirming the existence of a dominant factor that explains a significant part of the variance. The loss value was 0.668 after 27 iterations, indicating good convergence of the model. However, it can be observed in Figure 1 that two variables (V76 and V77) move away from the rest, which could suggest that these items affect the lack of a better model fit.

In any case, this evidence indicates that unidimensionality of the scale cannot be ruled out and the use of Item Response Theory (IRT) models is justified.

The Graded Response Model (GRM) was fitted to the data to assess the psychometric properties of the scale. The maximum likelihood indices (log., Lik= -11699.62 ; g.l=84) AIC (23567.24) and BIC (23947.59) indicate that the model fits the data adequately, maintaining a balance between accuracy and model complexity.

Table 3 shows the estimated parameters for each item, including discrimination values (Dscrmn) and response category thresholds (Extrmt).

FIGURE 1. Categorical principal components

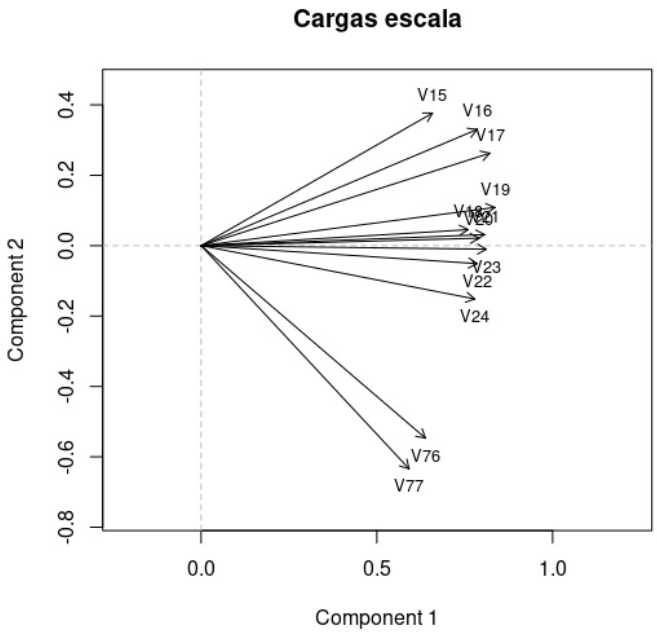


TABLE 3. Parameters of MRG items

Item	Discrimination	Threshold 1	Threshold 2	Threshold 3	Threshold 4	Threshold 5	Threshold 6
V15	1.633	-2.213	-1.179	-0.383	0.457	1.398	2.420
V16	2.432	-1.302	-0.481	0.109	0.813	1.639	2.345
V17	2.668	-1.198	-0.407	0.274	0.857	1.566	2.420
V18	2.216	-0.021	0.610	1.063	1.660	2.252	2.947
V19	2.756	-0.765	-0.035	0.506	1.139	1.749	2.720
V20	2.287	-0.692	0.026	0.510	1.126	1.845	2.776
V21	2.469	-1.153	-0.287	0.338	0.955	1.628	2.370
V22	2.254	-1.012	-0.173	0.418	1.060	1.676	2.419
V23	2.519	-0.958	-0.124	0.503	1.133	1.758	2.360
V24	2.146	-0.203	0.523	1.062	1.662	2.340	3.213
V77	1.180	-0.675	0.295	1.022	1.795	2.678	3.659
V76	1.354	-0.406	0.444	1.177	1.862	2.546	3.330

It can be observed that most of the items have high discrimination values, with items such as V16 (2.432), V17 (2.668), and V19 (2.756) making them stand out in terms of their ability to differentiate between people with high and low levels of knowledge.

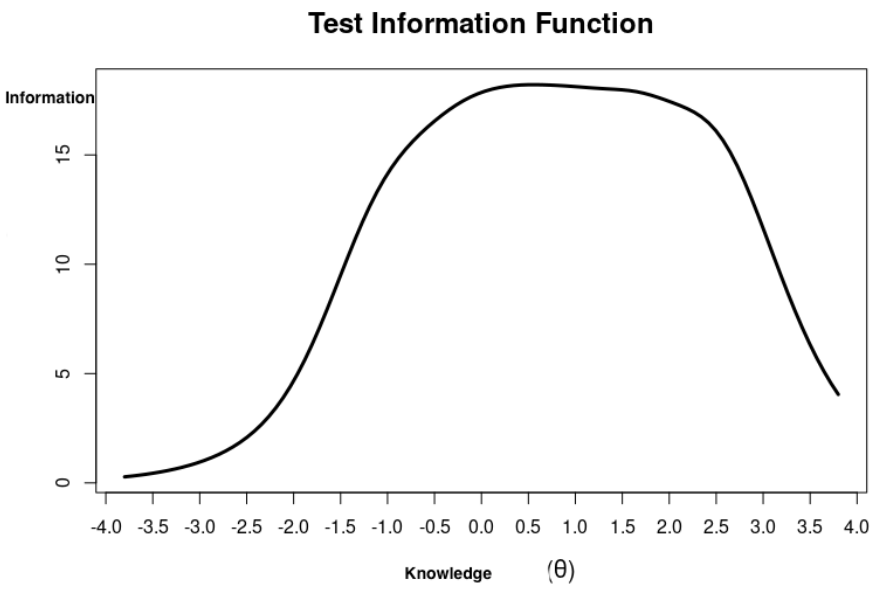
With respect to the item thresholds, it is observed that they are well distributed along the latent trait (knowledge) continuum, indicating that the items can capture a wide range of proficiency levels. For example, item V15 has thresholds ranging from -2.213 to 2.420, covering a wide range of difficulty.

An analysis of the information function of the model was then carried out to assess the accuracy of the scale at different levels of competence in order to get an overview of how much information the items provide in the various parts of the knowledge continuum of the participants.

The total information provided by the scale is 88.98. Of this, 86.89 information units, representing 97.65% of the total, are in the -4 to 4 range on the latent trait continuum. The fact that almost all the information is concentrated in the -4 to 4 range indicates that the scale is extremely accurate in measuring knowledge within this interval.

To visualise the accuracy of the test at different proficiency levels, the graph (Figure 2) of the information function of the Graduated Response Model (GRM) was generated. This graph shows how the amount of information provided by the items varies along the knowledge continuum. The peaks in the graph indicate where the scale is most informative and therefore most accurate at those levels. This means that the scale has a high ability to discriminate between individuals in those specific ranges. Furthermore, the high amount of information in the central range suggests that the scale's estimates of participants' knowledge will be accurate and reliable for most participants.

FIGURE 2. **Graph of the information function of scale**



The analysis of the factor scores and item responses provides a comprehensive picture of the level of knowledge about ICT used with people with functional diversity in the sample studied. The mean latent score is approximately -0.021, suggesting that, on average, participants have a level of knowledge close to the mean of the latent trait. The latent scores range from -2.32 to 3.68, indicating a wide dispersion in knowledge levels among participants.

The mean standard error is 0.236, suggesting high precision in the estimation of latent scores. Standard errors range from 0.061 to 0.496, indicating that most estimates of latent scores are fairly accurate. A low standard error is necessary to ensure the reliability of the measurements, as it suggests that the estimates of the latent scores are consistent and replicable.

These results reflect a significant diversity in the participants' knowledge of ICT applied to people with functional diversity. The wide variation in latent scores may imply the need to generate and/or design training plans that address digital teaching competences for educational inclusion. Furthermore, the accuracy in estimating latent scores supports the validity of the measurement instrument, indicating that it is adequate to capture the subtleties and nuances of knowledge in this specific area.

4. DISCUSSION

A psychometric analysis based on IRT has been carried out that resolves some of the limitations of Classical Test Theory when validating instruments. In addition, it is necessary to take into account some limitations that the validation process had in its original publication. Thus, the high internal consistency of the original scale (Cabero-Almenara et al., 2016) suggests an excessive internal consistency that may suggest the existence of a redundancy problem in the measure (Panayides, 2013). The latent structure was identified from a Principal Component Analysis, to whose results matrix they applied a Varimax rotation, which suggests a classical approach to the psychometric problem, although it has been superseded in recent decades (Widaman, 2007). In this study, only one subscale has been used, considerably reducing its length and facilitating its use with screening tests. The information function of the scale indicates that it provides very reliable estimates for most of the people assessed.

Overall, most of the fit values between pairs of items are within an acceptable range, indicating that the MRG model adequately captures the relationships between most of the items. However, they also suggest areas where the model may be less accurate due to fit problems with the V77-V76 pair, an issue that is graphically observed in the categorical principal components analysis (Figure 1).

The results show that the scale used is not only effective in measuring the average knowledge of the participants, but it is also able to detect significant variations between individuals, which is essential for designing more effective educational interventions and training programmes. The accuracy of the estimates reinforces confidence in the results obtained (López-Falcón, 2021), providing a solid basis for future research and practical applications in the field of ICT education and teacher training for people with functional diversity (Ari et al., 2022; Blasco-Serrano et al., 2022; Kerexeta-Brazal et al., 2022).

These results indicate that the University of Granada provides more effective ICT training, reflected in the higher and less dispersed scores of its students. In contrast, students from "Other universities" and the University of Malaga have lower levels of ICT knowledge than the overall average, with greater diversity in proficiency levels within the "Other universities" group. These findings highlight the importance of institutional context in ICT training, suggesting the need to adapt educational programmes to address differences in knowledge levels (Cabero-Almenara et al., 2022; Díaz-García et al., 2020).

Research by Masoumi (2021), Pinto-Santos (2023), Recio-Muñoz et al. (2020) and Silva et al. (2018), for example, argues that comprehensive training in the promotion of digital skills is essential, as teachers are at a basic level in terms of ICT knowledge and management, i.e. they know basic technological tools, but find it more complex to perform advanced tasks such as creating content or activities using technology. Likewise, the results of a study carried out by Guillén-Gámez et al. (2020) corroborate that future teachers have a low level of ICT use in the classroom and show that the degree of digital competence and motivation to use ICT are variables that are positively correlated.

The study underlines the importance of socio-demographic variables in the level of ICT knowledge. Men, students from certain universities, and those who have received ICT training show higher levels of knowledge, which we value from the point of view of critical enquiry and the potential of the scale used for the improvement of initial teacher training in educational innovation and inclusion. Furthermore, these findings highlight the need to consider these differences when designing educational and training programmes, with the aim of addressing knowledge gaps and promoting equitable and effective training in educational technology. This same idea is highlighted in a study by Nieto-Isidro et al. (2022) on the relationship between information literacy and socio-demographic variables in teachers and future teachers in compulsory education.

5. CONCLUSIONS

Educational inclusion requires changes in teaching-learning methods and ICT offers the necessary tools to make these adjustments efficiently, becoming a fundamental resource for the promotion of equity and quality in education. ICT not only facilitates access to learning and communication, but also fosters collaboration, autonomy and active participation of students with functional diversity in pedagogical processes. These resources need to be appropriately integrated to ensure that all learners have the opportunity to reach their full potential, regardless of their individual abilities.

The fit of the MRG model to the data was satisfactory, as indicated by the fit indices (log.Lik, AIC, BIC). The discrimination parameters suggest that most of the items are effective in differentiating levels of competence, and the well-distributed thresholds ensure a wide coverage of the range of competence of the latent trait. These results support the validity of using the MRG model to assess prospective teachers' knowledge of ICT for diversity.

The analysis of the information function confirms that the scale is highly effective in measuring prospective teachers' knowledge of ICT for diversity. On the other hand, the interpretation of the latent scores suggests that the sample has a distribution of ICT for diversity knowledge centred close to the mean.

The implementation of this scale not only makes it possible to assess the digital and inclusive competences of future teachers, but also to raise awareness and advocate for the need to reformulate teacher training plans to meet the demands of a highly heterogeneous society. It therefore serves as a predictive tool to identify training gaps and develop training programmes that respond to these needs. This represents a step forward in generating scientific knowledge within the paradigm of inclusive education, in need of resources and instruments to move towards a true educational transformation that avoids para-scientific parameters or, where appropriate, occurrences rather than fully reliable and valid evidence in terms of democratic, rational and human rights-based pedagogical construction.

The evolution of ICT and diversity in the classroom require continuous teacher training and the design and/or revision of scales to assess digital competences for inclusive education. These measurement tools facilitate the understanding of the level of knowledge of future teachers and improve both teacher training and the quality of education. The aim is to continue transforming education based on scientific-technical criteria that enable the understanding of a reality that is key to educational quality: the challenge of educational inclusion. Teachers need this type of instruments that can and should be shared to increase their commitment to diversity and digital competences applied to pedagogical-inclusive responses that are the bearers of more revitalising, dynamic, innovative and creative meanings in the new school scenarios.

5.1. Limitations and future lines of research

There is a significant fit problem between items V77 and V76. This finding indicates the need to revise these items to improve the validity and reliability of the scale.

Overall, the results support the use of the MRG model, but also highlight areas for improvement in the formulation and evaluation of some specific items.

For future research, it would be interesting to design a scale on digital teaching competences for inclusion that includes emerging ICT competences such as artificial intelligence, big data analysis and cybersecurity, among others. These latter challenges are key elements in addressing the complexity of a school that is progressively facing the translation of cultural and technological challenges in a hybrid, interconnected and networked world.

6. ACKNOWLEDGMENTS

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7. REFERENCES

Almerich, G., Suárez-Rodríguez, J., Díaz-García, I., & Orellana, N. (2020). Structure of 21st century competencies in students in the educational field. Influential personal factors. *Educación XX1, 23*(1), 45-74. https://doi.org/10.5944/educXX1.23853

Ari, R., Altinay, Z., Altinay, F., Dagli, G., & Ari, E. (2022). Sustainable management and policies: the roles of stakeholders in the practice of inclusive education in digital transformation. *Electronics, 11*(4), 1-16. https://doi.org/10.3390/electronics11040585

Baker, F., & Kim, S.H. (2004). *Item Response Theory.* Marcel Dekker.

Bentler, P. M. (1990). Comparative fit indexes in structural models. *Psychological Bulletin, 107*(2), 238-246. https://doi.org/10.1037/0033-2909.107.2.238

Blasco-Serrano, A. C., Bitrián-González, I., & Coma-Roselló, T. (2022). Incorporation of ICT in initial teacher training through Flipped Classroom to promote inclusive education. *EDUTEC, (*79), 9-29. https://doi.org/10.21556/edutec.2022.79.2393

Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen & J. S. Long (Eds.), *Testing structural equation models* (pp. 136-162). Sage.

Cabero-Almenara, J., Fernández-Batanero, J. M., & Córdoba-Pérez, M. (2016). Knowledge of ICT applied to people with disabilities. Construction of a diagnostic instrument. *Magis, International Journal of Research in Education, 8*(17), 157-176. https://doi.org/10.11144/Javeriana.m8-17.ctap

Cabero-Almenara, J., Guillén-Gámez, F. D., Ruiz-Palmero, J., & Palacios-Rodríguez, A. (2022). Teachers' digital competence to assist students with functional diversity: Identification of factors through logistic regression methods. *British Journal of Educational Technology, 53*(1), 41-57. https://doi.org/10.1111/bjet.13151

Cabero-Almenara, J., & Martínez, A. (2019). Information and communication technologies and initial teacher education: digital models and competences. *Profesorado, Revista de Currículum y Formación de Profesorado, 23*(3), 247-268. https://doi.org/10.30827/profesorado.v23i3.9421

Chou, Y.T., & Wang, W.C. (2010). Checking Dimensionality in Item Response Models With Principal Component Analysis on Standardized Residuals. *Educational and Psychological Measurement, 70*(5), 717-731. https://doi.org/10.1177/0013164410379322

Colás-Bravo, M. P., & Buendía-Eisman, L. (1998). *Educational research (*3rd ed.). Alfar.

Díaz-García, I., Almerich-Cerveró, G., Suárez-Rodríguez, J., & Orellana-Alonso, N. (2020). The relationship between ICT competences, ICT use and learning approaches in university education students. *Journal of Educational Research, 38*(2), 549-566. https://doi.org/10.6018/rie.409371

Ferrando, P.J., Lorenzo-Seva, U., Hernández-Dorado, A., & Muñiz, J. (2022). Decalogue for the Factorial Analysis of Test Items. *Picothema, 34*(1), 7-17. https://doi.org/10.7334/psicothema2021.456

Gallardo-Montes C. P., Caurcel-Cara, M. J., Crisol-Moya, E., & Peregrina-Nievas, P. (2023). ICT Training Perception of Professionals in Functional Diversity in Granada. *International Journal of Environmental Research and Public Health, 20*(3), 2064. https://doi.org/10.3390/ijerph20032064

Guillén-Gámez, F. D., Mayorga-Fernández, M. J., & Álvarez-García, F. J. (2020). A Study on the Actual Use of Digital Competence in the Practicum of Education Degree. *Tech Know Learn, 25*, 667-684. https://doi.org/10.1007/s10758-018-9390-z

Harman, H. H. (1976). *Modern factor analysis (3rd ed.).* University of Chicago Press.

Hooper, S., & Rieber, L. P. (1995). Teaching with technology. In A. C. Ornstein (Ed.), *Teaching: Theory into practice* (154-170). Allyn and Bacon.

Instituto Nacional de Tecnologías del Aprendizaje y de Formación del Profesorado [INTEF] (2022). *Marco de Referencia de la Competencia Digital Docente.* INTEF. http://aprende.intef .en/mccdd

Kerexeta-Brazal, I., Darretxe-Urrutxi, L., & Martínez-Monje, P. M. (2022). Digital competence in teaching and educational inclusion at school. A systematic review. *Campus Virtuales, 11*(2), 63-73. https://doi.org/10.54988/cv.2022.2.885

Krumsvik, R. J. (2014). Teacher educators' digital competence. *Scandinavian Journal of Educational Research, 58*(3), 269-280. https://doi.org/10.1080/00313831.2012.726273

Lai, K., & Green, S. B. (2016). The Problem with Having Two Watches: Assessment of Fit When RMSEA and CFI Disagree. *Multivariate Behavioral Research, 51*(2-3), 220-239. https://doi.org/10.1080/00273171.2015.1134306

Laitón, E.V., Gómez, S.E., Sarmiento, R.E., & Mejía, C. (2017). Inclusive practice competence: ICT and inclusive education

in teacher professional development. *Sophia 13*(2), 82-95. https://doi.org/10.18634/sophiaj.13v.2i.502

López-Falcón, A. (2021). The types of research results in educational sciences. *Revista Conrado*, *17*(S3), 53-61.

Lorenzo-Seva, U., Timmerman, M. E., & Kiers, H. A. L. (2011). The Hull method for selecting the number of common factors. *Multivariate Behavioral Research, 46*(2), 340-364. https://doi.org/10.1080/00273171.2011.564527

Masoumi, D. (2021). Situating ICT in early childhood teacher education. *Education and Information Technologies, 26*, 3009-3026. https://doi.org/10.1007/s10639-020-10399-7

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

Moriña, A. (2020). Faculty members who engage in inclusive pedagogy: Methodological and effective strategies for teaching. *Teaching and Higher Education*, *27*(3), 1-16. https://doi.org/10.1080/13562517.2020.1724938

Nieto-Isidro, S., Martínez-Abad, F., & Rodríguez-Conde, M. J. (2022). Observed and Self-perceived Informational Competence in teachers and future teachers and its relationship with socio-demographic variables. *Revista de Educación,* (396), 35-64. https://doi.org/10.4438/1988-592X-RE-2022-396-529

Panayides, P. (2013). Coefficient Alpha: Interpret With Caution. *Europe's Journal of Psychology*, *9*(4), 687-696. https://doi.org/10.5964/ejop.v9i4.653

Parody-García, L. M. (in press). *New trends in initial and in-service teacher training for the development of digital competences applied to inclusive education. Pedagogical realities and challenges.* [Doctoral thesis]. University of Malaga.

Parody-García, L.M., Leiva-Olivencia, J.J., & Santos-Villalba, M.J. (2022). Universal Design for Learning in Digital Teacher Training from an Inclusive Pedagogical View. *Revista Latinoamericana de Educación Inclusiva, 16*(2), 109-123. https://dx.doi.org/10.4067/S0718-73782022000200109

Parra, L., & Agudelo, A. (2020). Innovation in ICT-mediated pedagogical practices. In R. Canales & C. Herrera (eds.). *Access, democracy and virtual communities (*pp. 51-64). CLACSO.

Pegalajar, M. C. (2017). Future teachers and the use of ICT for inclusive education. *Digital Education Review*, (31), 131-148.

Pinto-Santos, A. R., Pérez-Garcias, A., & Darder-Mesquida, A. (2023). Digital competence training for teachers: functional validation of the TEP model. *Innoeduca. International Journal of Technology and Educational Innovation, 9*(1), 39-52. https://doi.org/10.24310/innoeduca.2023.v9i1.15191

R Core Team (2022). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.

Recio-Muñoz, F., Silva-Quiroz, J., & Abricot-Marchant, N. (2020). Analysis of digital competence in the initial training of university students: A meta-analysis study in the Web of Science. *Pixel-Bit. Journal of Media and Education,* (59), 125-146. https://doi.org/10.12795/pixelbit.77759

Ripoll-Rivaldo, M. (2021). Pedagogical practices in teacher training: from the didactic axis. *Telos: Revista de Estudios Interdisciplinarios en Ciencias Sociales, 23*(2), 286-304. https://doi.org/10.36390/telos232.06

Rizopoulos, D. (2006). ltm: An R Package for Latent Variable Modeling and Item Response Analysis. *Journal of Statistical Software, 17*(5), 1-25. https://doi.org/10.18637/jss.v017.i05

Romero-Martínez, S. J., & Ordóñez-Camacho, X. G. (2015). *Psychometrics*. Centro de Estudios Financieros.

Samejima, F. (1969). *Estimation of Latent Ability using a Response Pattern of Graded Scores.* Psychometrika Monograph Supplement.

Silva, J., Lázaro, J. L., Miranda, P., & Canales, R. (2018). The development of teachers' digital competence during teacher training. *Opción, 34*(86), 423-449.

Tejedor, F. J., García-Valcárel, A., & Prada, S. (2009). Measuring university teaching staff attitudes towards ICT integration. *Comunicar, 17*(33), 115-124. https://doi.org/10.3916/c33-2009-03-002

United Nations Educational, Scientific and Cultural Organization [UNESCO] (2019). *ICT Competency Framework for Teachers.* UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000371024

Van der Linden, W.J., & Hambleton, R.K. (1997). *Handbook of Modern Item Response Theory.* Springer.

Vigo, M.B. (2021). Development of creative and inclusive teaching practices with digital media. In C. Latorre and A. Quintas (Coords.), *Inclusión educativa y tecnologías para el aprendizaje* (pp.129-144). Octaedro.

Widaman, K. F. (2007). Common factors versus components: Principals and principles, errors, and misconceptions. In R. Cudeck & R. C. MacCallum (Eds.), *Factor analysis at 100: Historical developments and future directions* (pp. 177-203). Lawrence Erlbaum Associates.

Wismeijer, A. A. A. J., Sijtsma, K., van Assen, M. A. L. M., & Vingerhoets, A. J. J. J. M. (2008). A Comparative Study of the Dimensionality of the Self-Concealment Scale Using Principal Components Analysis and Mokken Scale Analysis. *Journal of Personality Assessment, 90*(4), 323-334. https://doi.org/10.1080/00223890802107875

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Technostress levels of science field faculty members in the Kyrgyz Republic

Niveles de tecnoestrés del profesorado de ciencias de la República Kirguisa

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ABSTRACT

The purpose of this study was to examine the technostress levels of science field faculty members in the Kyrgyz Republic. The relational survey model was used to investigate whether there was a significant difference and a relationship between demographic variables such as gender, age, field of science, seniority, technological education level, and availability of a personal computer in terms of technostress and its sub-dimensions. The sample of the study consisted of 274 science faculty members, with 156 females and 118 males working at different universities in the Kyrgyz Republic. “Personal Data Form” and “Defining Teachers’ Technostress Levels Scale” were used as data collection tools in the study. The results showed that the general technostress levels of the participants were at a medium level. General technostress levels and technostress

sub-dimensions scores of science faculty members did not differ by their genders, ages, seniorities, technology educations, and availability of their computers. There was a low level of positive correlation between age and the scores of the occupational and personal sub-dimensions of technostress; It was determined that there was a low-level, positive, statistically significant relationship between the seniority variable and the personal-oriented sub-dimension. It can be concluded that as the year of seniority progresses, academicians' technostress scores also increase. These findings reveal that seniority has certain effects on the technostress levels of academicians, but these effects vary based on sub-dimensions.

KEYWORDS Higher education; technology in education; technological competence; technostress.

RESUMEN

El objetivo de este estudio era examinar los niveles de tecnoestrés de los profesores de ciencias de la República Kirguisa. Se utilizó el modelo de encuesta relacional para investigar si existía una diferencia significativa y una relación entre variables demográficas como el género, la edad, el campo de la ciencia, la antigüedad, el nivel de educación tecnológica y la disponibilidad de un ordenador personal en términos de tecnoestrés y sus subdimensiones. La muestra del estudio estaba formada por 274 profesores de ciencias, de los cuales 156 eran mujeres y 118 hombres que trabajaban en distintas universidades de la República Kirguisa. En el estudio se utilizaron como herramientas de recogida de datos el "Formulario de datos personales" y la "Escala de definición de los niveles de tecnoestrés de los profesores". Los resultados mostraron que los niveles generales de tecnoestrés de los participantes se situaban en un nivel medio. Los niveles generales de tecnoestrés y las puntuaciones de las subdimensiones de tecnoestrés de los profesores de ciencias no diferían en función de su sexo, edad, antigüedad, formación tecnológica y disponibilidad de ordenadores. Hubo un bajo nivel de correlación positiva entre la edad y las puntuaciones de las subdimensiones laboral y personal del tecnoestrés; Se determinó que existía una relación de bajo nivel, positiva y estadísticamente significativa entre la variable antigüedad y la subdimensión de orientación personal. Se puede concluir que a medida que avanza el año de antigüedad, también aumentan las puntuaciones de tecnoestrés de los académicos. Estos resultados revelan que la antigüedad tiene ciertos efectos sobre los niveles de tecnoestrés de los académicos, pero estos efectos varían en función de las subdimensiones.

PALABRAS CLAVE Enseñanza superior; tecnología en la educación; competencia tecnológica; tecnoestrés.

1. INTRODUCTION

Modern societies produce new technologies using the information they obtain through science and thus accelerate social change. New technology, with all its evolution, has been and continues to be the subject of numerous studies and research highlighting its positive and negative aspects (Chiappetta, 2017). By their own characteristics, technological and social changes are closely interconnected. Especially in modern societies, rapid technological change is accompanied by rapid social change. The level of development of today's society is generally measured by the science and technology it produces. There is only one way to achieve this, and that is education. Along with technological innovations, educational tools and equipment also need to be updated by the demands of the age. One of the key issues in this environment that develops with digital transformation is the need to bring technological quality to education. Education that does not benefit from technological opportunities cannot meet the social and individual expectations and needs of the age (Karasar, 2004). In addition to the use of technology in curriculum and evaluations, it also becomes necessary to encourage educators to include technology in teaching in order to facilitate learning, considering the education factor (Scherer et al., 2019).

In addition to the benefits of technology in the learning and teaching processes, it is known that the use of technology in academic studies by faculty members provides great convenience in their research. In order

to integrate technology into education, it is known that educators must first be aware of this issue and have a positive perspective on the use of technology. However, understanding the factors that encourage and/or restrict educators to use information and communication technologies is considered crucial for an effective technology adaptation process (Ursavaş et al., 2014). Today's widespread use of technological tools and internet applications has placed a responsibility on teachers to use technological tools for educational purposes 24/7, not only in the school building and during working hours, but also outside working hours. Thus, teachers need to work harder in both their professional and social lives, and their responsibilities increase (Çetin & Bülbül, 2017). On the other hand, today's digital age children grow up with technology and have the skills to use technological tools. The fact that children grow up in technology places responsibilities on the teachers who will educate them in ensuring and enriching the integration of technology into educational environments (Gökbulut, 2021). Another condition for success in integrating technology into learning-teaching processes is that teachers feel psychologically comfortable when they turn to technology. When some teachers spend a long time with technology, they narrow down their personal space, encounter more information and data than they can process, or when they want to improve themselves technologically - more specifically in terms of changing teaching technologies - as a result of intense experiences, or they may feel stress due to their lack of knowledge and experience (Erdoğan & Akbaba, 2022).

The negative effects experienced by people due to technology were first defined as "Technostress" by the American psychologist Brod (1984). He defines the technostress as a modern adaptation disease caused by the inability to cope with new computer technologies in a healthy way (Brod, 1984). He argues that technostress is a type of adjustment disorder (Chiappetta, 2017; Çoklar et al., 2017). However, in another definition he states that "technostress is not a disease, but a negative psychological, behavioral and physiological effect caused directly or indirectly by technology" (Clark, 1996). Brod (1984) listed the most important symptom of technostress in users as anxiety towards computer technologies and others as follows: muscle cramps, joint pain, headaches and insomnia (as cited in Çoklar et al., 2016). Technostress, as a type of stress caused by technology, causes the individual to be under stress and give some reactions (anger, anxiety, restlessness, fear) (Weil & Rosen, 1997). There are many studies in the literature that have examined the impact of technostress on individuals' lives. High technostress levels in individuals cause a decrease in job satisfaction, organizational commitment and job performance, while increasing negative emotions (Ayyagari et al., 2011; Jena, 2015; Tarafdar et al., 2011). In other words, technostress is directly related to technology.

Studies in the literature that have examined the technostress levels of teachers and the relationship of technostress with other phenomena are: job satisfaction (Aktan & Toraman, 2022; Ranathunga & Rathnakara, 2022; Toraman & Aktan, 2022), professional motivation (Akman & Durgun, 2022), academic productivity (La Torre et al., 2020; Lee et al., 2016; Upadhyaya & Vrinda, 2021), satisfaction, anxiety, and performance (Abd Aziz et al., 2021; Fernández-Fernández et al., 2023; Rodríguez-Barboza, 2023) , academic success and well-being (Whelan at al., 2022), techno-pedagogical competence (Gökbulut, 2021), professional burnout (Gökbulut & Dindaş, 2022), perceived organizational support (Solís et al., 2023), job satisfaction and perceived performance (Al-Ansari & Alshare, 2019), work engagement and work-life balance satisfaction (Curcuruto et al., 2023), psychological capital (Efilti & Çoklar, 2019), work-family conflict (Shaukat et al., 2022). However, there are also studies examining the relationship between technostress and life satisfaction (Le Roux & Botha, 2021; Lee et al., 2016; Shaukat et al., 2022).

1.1. Literature review

Brod (1984) defines technostress as a modern adaptation disease caused by the inability to cope with new computer technologies healthily, and this stress situation occurs when the expertise requirements of information and correspondence technologies exceed the capacity level of users (Sharma & Gupta, 2022). In the literature, there are some studies examining the effects of technostress on individuals' lives. High levels of technostress in individuals may lead to a decrease in job satisfaction, organizational commitment and job performance, and an increase in negative emotions (Ayyagari et al., 2011; Jena, 2015; Tarafdar et al., 2011); reduces job satisfaction (Aktan & Toraman, 2022; Ranathunga & Rathnakara, 2022; Toraman & Aktan, 2022); may cause low professional motivation (Akman & Durgun, 2022); negatively affects academic productivity (La Torre et al., 2020; Lee et al., 2016; Upadhyaya & Vrinda, 2021); increases professional burnout (Gökbulut & Dindaş, 2022); affects life satisfaction (Le Roux & Botha, 2021; Lee et al., 2016; Shaukat et al., 2022); triggers work-life balance satisfaction (Curcuruto et al., 2023); reduces individuals' work participation and psychological capital levels (Efilti & Çoklar, 2019); may cause a decrease in the level of work performance (Abd Aziz et al., 2021; Al-Ansari & Alshare, 2019; Fernández-Fernández et al., 2023; Rodríguez-Barboza, 2023) and may be one of the factors affecting work-family conflict (Shaukat et al. al., 2022). There are some studies examining the relationship between technostress and gender variables. Some of these studies found that technostress levels of teachers did not differ by the gender variable (Akman & Durgun, 2022; Arslan et al., 2022; Çetin & Bülbül, 2017; Çoklar et al., 2016; Gökbulut, 2021; Le Roux & Botha, 2021; Li & Wang, 2021; Özgür, 2020; Yadav & Rahaman, 2020). However, some of these studies claimed that the level of technostress might differ according to gender (Abd Aziz et al., 2021; Akgün, 2019; Aktan & Toraman, 2022; Çoklar & Şahin, 2011; Gökbulut & Dindaş, 2022; Lee et al., 2014; Ragu-Nathan et al., 2008; Riedl, 2013; Shaukat et al., 2022; Shu et al., 2011; Upadhyaya & Vrinda, 2021). Other studies have examined the relationship between professional seniority and technostress (Marchiori et al., 2019; Penado Abilleira et al., 2021). As a striking factor during the literature review process, it was observed that there were very few studies focusing on the relationship between technostress and variables such as the field of science, technological education, and access to computers.

The negative effects experienced by people due to technology were first defined as "Technostress" by the American psychologist Brod (1984). He defines the technostress as a modern adaptation disease caused by the inability to cope with new computer technologies in a healthy way (Brod, 1984). He argues that technostress is a type of adjustment disorder (Chiappetta, 2017; Çoklar et al., 2017). However, in another definition, he states that "technostress is not a disease, but a negative psychological, behavioral and physiological effect caused directly or indirectly by technology" (Clark, 1996). Wang et al. (2008) defines technostress as the pressure created by other people or responsibilities regarding the use of technology on individuals as a result of the importance of technology use skills in work environments. Brillhart (2004) stated that technostress starts with the employees, starting from the planning of business meetings, and tracking the work, and many digital content technologies create technostress on the employees in the enterprises, causing anxiety. Coppari et al. (2018) defined technostress as an emotional, physical, and cognitive difficulty that causes fatigue or exhaustion due to inappropriate use of technologies. Brod (1984) listed the most important symptom of technostress in users as anxiety towards computer technologies and others as follows: muscle cramps, joint pain, headaches, and insomnia (as cited in Çoklar et al., 2016). Technostress, as a type of stress caused by technology, causes the individual to be under stress and give some reactions (anger, anxiety, restlessness, fear) (Weil & Rosen, 1997). In other words, technostress is directly related to technology.

Wang, et al., 2023 investigated psycho-emotional factors on students' technology acceptance. As results showed students achievement and emotions, and technological self-efficacy were significant predictors of technology acceptance. Teachers' technology acceptance and emotional intelligence were investigated by Zhi et al., (2023). Structural equation modeling and regression analysis were conducted, and results showed that 89% and 63% of variances were predicted by emotional intelligence and self-efficacy of Chinese EFL teachers' technology adoption.

Factors that create technostress: Factors frequently used to explain technostress factors are: 1) techno-overload, 2) techno-invasion, 3) techno-complexity, 4) techno-uncertainty and 5) techno-insecurity (Ragu-Nathan et al., 2008; Singh et al., 2022; Tarafdar et al., 2007, 2011). Techno-overload refers to the need to process information from multiple tasks simultaneously using technological devices. Techno-invasion occurs when technology invades personal life and privacy, creating the need to connect anytime, anywhere. Techno-complexity is defined as the complexity associated with the use of technology and means putting in the time and effort to learn how to use technology effectively. Techno-uncertainty is since technology is a stressful factor due to constant updates and changes, making it difficult for users to establish a solid foundation of experience and domain in using technology. Techno-insecurity is the feeling that technology threatens job stability and maintenance of employment (Araoz et al., 2023).

It is possible to identify different categories for prevention and intervention strategies. Primary prevention focuses on increasing the knowledge of affected individuals, who should focus on preventive aspects to avoid technostress. On the other hand, when technostress symptoms are already present, secondary intervention is applied and is carried out through direct training by experts. Finally, the tertiary strategy is applied in cases where technostress occurs aggressively and with all its consequences and requires the provision of psychological and medical support to confront it effectively (Salanova et al., 2011).

1.2. Research questions

As the literature review shows, the inadequacy of teachers in technology causes technostress, which negatively affects their job performance. Based on the research problem and the findings in the literature, the purpose of the research is to examine the technostress levels of university science faculty members based on some variables. The starting point of the study is the proliferation of information communication technologies across organizations therefore affecting people who are not technology experts, and the limited number of studies conducted on the subject by faculty members in science fields. Science faculty members are chosen as the research universe due to their close interaction with technology, reliance on digital tools, and the need to adapt swiftly to technological advancements. Therefore, the study focused on faculty members, who are non-technologist experts who are exposed to information communication technologies as a regular part of their workday. Additionally, it is believed that the study will fill these gaps by examining the technostress levels of academicians in terms of some variables in a developing country such as the Kyrgyz Republic, where online teaching is a relatively new concept and universities have just started to create and offer online programs. In this context, the researcher used the following research questions to achieve the purpose of the study:

1. What are the technostress levels of science faculty members?
2. Do the technostress levels of science faculty members differ by their demographic variables (gender, age, science field, professional seniority, technological education level, and personal computer availability)?

3. Is there a significant relationship between age and seniority variables and technostress levels of science faculty members?

2. MATERIAL AND METHOD

In the study, the situation was determined using the relational survey model among the quantitative research methods. While survey models are defined as research approaches that aim to describe a past or ongoing situation as it exists, relational survey models are defined as research models that aim to determine the existence or degree of change between two or more variables (Karasar, 2014). In addition, the individual or object subject to research is tried to be defined as it is and within its conditions. In addition, this model is the model in which participant opinions on a topic or event are determined (Büyüköztürk, 2021).

2.1. Population and Sample

The population of the study consisted of science faculty members working at universities in the Kyrgyz Republic in the 2022-2023 academic year. It consisted of 274 science faculty members working at different universities in the Kyrgyz Republic who agreed to participate in the study voluntarily. In determining the sample, a simple random sampling technique was used, where participants were selected randomly (Ekiz, 2015; Lavrakas, 2008). Demographic and descriptive statistical data about the sample group is presented in Table 1:

TABLE 1. Demographic Characteristics of Participants (n=274)

	GROUP	n	%
Gender	Female	156	56,9
	Male	118	43,1
Age	27-40	80	29,2
	41-55	111	40,5
	56 and over	83	30,3
Field of Science	Chemistry	61	22,3
	Biology	75	27,4
	Mathematics	48	17,5
	Geography	49	17,9
	Informatics	41	15,0
Seniority	1-15 years	78	28,5
	16-30 years	115	42,0
	31 years and over	81	29,6
Getting technology education	Educated	166	60,6
	Uneducated	108	39,4
Having Personal Computer	Those who have a computer	160	58,4
	Those who do not have a computer	114	41,6

As seen in Table 1, 56.9% (n=156) of the sample of the study are females and 43.1% (n=118) are males. 40.5% (n=111) of the participants are between the ages of 41-55, 29.2% (n=80) are between the ages of 27-40, and 30.3% (n=83) are aged 56 and over by the age variable. 27.4% (n=75) of the participants studied in biology, 22.3% (n=61) studied in chemistry, 17.9% (n=49) studied in geography, 17.5% (n=48) studied in mathematics and 15% (n=41) studied in informatics. 42% (n=115) of the participants have 16-30 years of seniority, 28.5% (n=78) have 1-15 years of seniority, and 29.6% (n=81) have 31 years or more of seniority.

2.2. Data Collection Tools

The data was collected through the Personal Data Form created by the researcher, including demographic factors, and the "Defining Academicians' Technostress Levels Scale" developed by Çoklar et al. (2017) and adapted into Kyrgyz by Efilti and Zhumgalbekov (2023).

2.2.1. Personal Data Form

The form, created by the researcher, includes the demographic information of the participants (gender, age, field of science, seniority, technological education, and availability of personal computers).

2.2.2. Defining Academicians' Technostress Levels Scale

The scale was developed by Çoklar et al. in 2017. It consists of 28 items and 5 factors. The factors are "Learning-Teaching Process Oriented", "Profession Oriented", "Technical Issue Oriented", "Personal Oriented" and "Social Oriented". The scale items are 5-point Likert type and are "Totally Agree", "Agree", "Partly Agree", "Disagree" and "Strongly Disagree". The internal consistency coefficient (Cronbach's Alpha coefficient) for the whole scale was found to be .917, and the Spearman-Brown coefficient calculated for dividing into two halves was found to be .845. The internal consistency coefficient (Cronbach's Alpha coefficient) of the factors that make up the scale takes values between .712 and .788. The calculations made on the arithmetic mean score are based on the interpretation of the findings obtained depending on the analysis of the data. The criteria for evaluating the technostress levels of academicians in the scale are as follows: 1.00 – 2.33 – low level, 2.34 – 3.67 – medium level, 3.68 – 5.00 – high level (Çoklar et al., 2017).

A high positive correlation was determined between the original Turkish and Kyrgyz versions of the scale ($r=0.798$, $p<0.01$). As a result of the analysis, a measurement tool consisting of 27 items and 5 sub-dimensions explaining 63.74% of the total variance was obtained, and it was observed that the items in the sub-dimensions exactly matched the items in the original form. The internal consistency coefficient of the Kyrgyz version of the scale was calculated as $\alpha=0.95$ and the internal consistency coefficient of the 5 sub-dimensions ranged between 0.77-0.85. The correlation value of the test-retest method was calculated as 0.811 (Efilti & Zhumgalbekov, 2023).

2.3. Data Collection and Analysis

To collect data, the application method of the scales was created. The prepared form was applied to the target participants face-to-face by interviewers. Information on how to answer the questions was given on the first pages of the scales.

A statistical package application was used to analyze the data. To determine which test types, parametric or non-parametric tests, would be used in the analysis of the data, the normal distribution of the data was examined. In studies conducted in the field of social sciences, understanding whether the data has a normal distribution feature is mostly achieved by Skewness and Kurtosis values. If the values are between +1.5 and -1.5, it is accepted that the data fulfills the normality distribution condition (Tabachnick and Fidell, 2013).

TABLE 2. Kurtosis and Skewness Values of Data

VARIABLES	SKEWNESS	KURTOSIS
Technostress (Total Score)	**0,151**	**-0,063**
1. Learning-Teaching Process-Oriented	-0,014	-0,204
2. Profession-Oriented	0,453	0,003
3. Technical-Issue-Oriented	0,298	0,008
4. Personal-Oriented	0,219	-0,251
5. Social-Oriented	0,469	0,023

As seen in Table 2, the Kurtosis and Skewness values of the data are between -1.5 and +1.5. In addition, histogram, Q-Q Plot, Boxplot graphics, and Kolmogorov-Smirnov (K-S) (significance value for all scales was insignificant, $p \geq 0.05$) test results were examined to determine the normal distribution. Accordingly, it was understood that the data met the normal distribution condition and it was decided to use parametric tests. Having a normal distribution in measurements and using parametric tests gives stronger results (Pallant, 2017). For analyses on demographic variables, a t-test for independent samples and a One-Way ANOVA test was applied, and the Pearson Product Moment Correlation Test was applied for correlational analyses between dependent variables. If there was a significant difference in the results of the comparison tests obtained, the effect size of the significance was decided with the formula eta square (), and the eta square value of the effect size was reported.

3. RESULTS

In this section, first, the general situation regarding the participants' levels of technostress and its sub-dimensions was described, then this dependent variable was compared with various independent variables and its relationship status was examined. Table 3, in next page, shows the technostress levels of the participants.

TABLE 3. Descriptive Statistics and Cronbach's Alpha Values for Technostress and Sub-Dimensions

VARIABLES	N	x̄	SD	α	DEGREE
Technostress (Total Score)	**274**	**2,71**	**0,504**	**0,917**	**Medium**
1. Learning-Teaching Process-Oriented	274	2,76	0,587	0,746	Medium
2. Profession-Oriented	274	2,49	0,625	0,772	Medium
3. Technical-Issue-Oriented	274	2,95	0,641	0,797	Medium
4. Personal-Oriented	274	2,45	0,632	0,780	Medium
5. Social-Oriented	274	2,88	0,678	0,718	Medium

As seen in Table 3, the technostress average of the participants was found to be 2.71. Mean scores for technostress sub-dimensions were calculated as follows; 2.76 for learning-teaching process-oriented, 2.49 for profession-oriented, 2.95 for technical-issue-oriented, 2.45 for personal-oriented and 2.88 for social-oriented. The data presented in the table shows that among the technostress sub-dimensions, the personal-related and professional-oriented sub-dimensions have the lowest mean, and the technical-issue-oriented and social-oriented sub-dimensions have the highest mean. However, the overall technostress levels of the participants are at a medium level. Cronbach's Alpha coefficients of the variables reveal that the data are quite reliable.

To determine whether the technostress levels of academicians differ by gender variable, the t-test for independent samples was conducted. The analysis results of the test are presented in Table 4:

TABLE 4. T-test Results for Independent Samples Regarding the Differentiation of Technostress Levels Based on Gender Variable

	GENDER	n	x̄	SD	t	df	p
Technostress (Total Score)	**Female**	**156**	**2,74**	**0,512**	**1,121**	**272**	**0,263**
	Male	**118**	**2,67**	**0,50**			
1. Learning-Teaching Process-Oriented	Female	156	2,76	0,58	0,212	271	0,832
	Male	118	2,75	0,59			
2. Profession-Oriented	Female	156	2,55	0,60	1,874	271	0,062
	Male	118	2,41	0,64			
3. Technical-Issue-Oriented	Female	156	2,98	0,66	0,468	271	0,640
	Male	118	2,94	0,61			
4. Personal-Oriented	Female	156	2,45	0,62	0,141	271	0,888
	Male	118	2,44	0,64			
5. Social-Oriented	Female	156	2,94	0,71	1,601	271	0,111
	Male	118	2,81	0,62			

As seen in Table 4, the general technostress levels of the participants do not show a statistically significant difference based on the gender variable [$t(340)= 1.121$; $p>0.05$]. The scores regarding the technostress sub-dimensions do not show a significant difference based on the gender variable ($p>0.05$). However, it was found that both females and males had a medium-level technostress score.

Table 5 shows the differences in the technostress levels of the participants based on the age variable:

TABLE 5. One-Way ANOVA Test Results Regarding the Differentiation of Technostress Levels Based on Age Variable

	AGE	n	x̄	SD	F	df	p
Technostress (Total Score)	**1) 24-40**	**80**	**2,64**	**0,504**	**1,779**	**2**	**0,171**
	2) 41-55	**111**	**2,70**	**0,475**			
	3) 56 and over	**83**	**2,79**	**0,546**			
1. Learning-Teaching Process-Oriented	1) 24-40	80	2,74	0,554	0,647	2	0,525
	2) 41-55	111	2,72	0,581			
	3) 56 and over	83	2,82	0,627			
2. Profession-Oriented	1) 24-40	80	2,38	0,618	2,215	2	0,111
	2) 41-55	111	2,49	0,550			
	3) 56 and over	83	2,59	0,713			
3. Technical-Issue-Oriented	1) 24-40	80	2,87	0,653	1,679	2	0,188
	2) 41-55	111	2,96	0,610			
	3) 56 and over	83	3,05	0,664			
4. Personal-Oriented	1) 24-40	80	2,33	0,636	2,794	2	0,063
	2) 41-55	111	2,44	0,620			
	3) 56 and over	83	2,56	0,631			
5. Social-Oriented	1) 24-40	80	2,87	0,708	0,531	2	0,589
	2) 41-55	111	2,93	0,634			
	3) 56 and over	83	2,84	0,706			

Table 5 shows that the general technostress levels of the participants did not show a statistically significant difference based on the age variable [$F(2)= 1.779$; $p>0.05$]. It was determined that the scores regarding the technostress sub-dimensions did not show a significant difference based on the age variable ($p>0.05$).

Table 6 shows the differentiation of technostress levels of participants based on the field of science variable:

TABLE 6. One-Way ANOVA Test Results Regarding the Differentiation of Technostress Levels Based on the Field of Science Variable

	FIELD OF SCIENCE	n	x̄	SD	F	df	p	EFFECT SIZE ()	DIFFERENCE
Technostress (Total Score)	1. Chemistry	61	2,73	0,500	2,460	4	0,046*	0,03	4-5
	2. Biology	75	2,67	0,515					
	3. Mathematics	48	2,70	0,477					
	4. Geography	49	2,87	0,512					
	5. Informatics	41	2,54	0,493					
1. Learning-Teaching Process-Oriented	1. Chemistry	61	2,74	0,560	1,623	4	0,169		
	2. Biology	75	2,76	0,639					
	3. Mathematics	48	2,75	0,569					
	4. Geography	49	2,89	0,590					
	5. Informatics	41	2,57	0,521					
2. Profession-Oriented	1. Chemistry	61	2,55	0,626	2,936	4	0,021*	0,04	4-2 4-5
	2. Biology	75	2,38	0,603					
	3. Mathematics	48	2,49	0,605					
	4. Geography	49	2,69	0,631					
	5. Informatics	41	2,30	0,625					
3. Technical-Issue-Oriented	1. Chemistry	61	2,96	0,661	0,985	4	0,416		
	2. Biology	75	2,93	0,666					
	3. Mathematics	48	2,90	0,519					
	4. Geography	49	3,11	0,633					
	5. Informatics	41	2,88	0,699					
4. Personal-Oriented	1. Chemistry	61	2,46	0,623	3,290	4	0,012*	0,04	4-5
	2. Biology	75	2,38	0,609					
	3. Mathematics	48	2,48	0,643					
	4. Geography	49	2,67	0,654					
	5. Informatics	41	2,21	0,578					
5. Social-Oriented	1. Chemistry	61	2,82	0,686	0,870	4	0,483		
	2. Biology	75	2,93	0,695					
	3. Mathematics	48	2,91	0,667					
	4. Geography	49	2,96	0,632					
	5. Informatics	41	2,74	0,699					

*$p<0.05$

As seen in Table 6, it was determined that the general technostress levels of the participants showed a statistically significant difference based on the field of science variable [$F(4)= 2.460$; $p<0.05$]. The calculated eta-squared effect size coefficient showed that this difference had a low impact on the variance (=0.03). Among the technostress sub-dimensions, the scores of the learning-teaching process-oriented,

technical-issue-oriented, and social-oriented sub-dimensions did not differ based on the field of science variable (p>0.05), while the scores for the profession-oriented [F(4)= 2.936; p<0.05]. and personal-oriented technostress [F(4)= 3.290; p<0.05] sub-dimension scores were found to differ statistically significantly. To find out which groups this difference was between, the Tukey test was applied since the Levene test was not significant. As a result of the test, according to the technostress sub-dimension for the profession, between academicians in the field of geography and the field of biology and informatics, and according to the personal-oriented technostress sub-dimension, it was understood that there was a significant difference between academicians in the field of geography and the field of informatics. This shows that academicians in the field of geography have higher professional and personal technostress levels. The calculated eta-squared effect size coefficient shows that this difference has a low impact on the variance (=0.04).

Table 7 shows the differences in the technostress levels of the participants based on the variable of seniority:

TABLE 7. One-Way ANOVA Test Results Regarding the Differentiation of Technostress Levels Based on the Seniority Variable

	YEAR	n	x̄	SD	F	df	p
Technostress (Total Score)	1) 1-15	78	2,67	0,490	1,730	2	0,179
	2) 16-30	115	2,66	0,489			
	3) 31 and over	81	2,79	0,542			
1. Learning-Teaching Process-Oriented	1) 1-15	78	2,80	0,528	2,086	2	0,126
	2) 16-30	115	2,67	0,592			
	3) 31 and over	81	2,83	0,625			
2. Profession-Oriented	1) 1-15	78	2,45	0,589	1,153	2	0,317
	2) 16-30	115	2,45	0,581			
	3) 31 and over	81	2,57	0,714			
3. Technical-Issue-Oriented	1) 1-15	78	2,91	0,651	1,366	2	0,257
	2) 16-30	115	2,92	0,622			
	3) 31 and over	81	3,06	0,654			
4. Personal-Oriented	1) 1-15	78	2,34	0,668	2,726	2	0,067
	2) 16-30	115	2,42	0,606			
	3) 31 and over	81	2,57	0,619			
5. Social-Oriented	1) 1-15	78	2,87	0,695	0,088	2	0,916
	2) 16-30	115	2,90	0,630			
	3) 31 and over	81	2,86	0,731			

*p<0.05

As seen in Table 7, the general technostress levels of the participants [F(2)= 1.730; p>0.05] and it was determined that the scores regarding the technostress sub-dimensions did not show a statistically significant difference based on the seniority variable (p>0.05).

Table 8 shows the differentiation of the participants' technostress levels based on the variable of having technological education.

TABLE 8. T-test Results for Independent Samples Regarding the Differentiation of Technostress Levels Based on the Variable of Having Technological Education

	TECHNOLOGICAL EDUCATION	n	x̄	SD	t	df	p
Technostress (Total Score)	Have	166	2,69	0,512	-0,393	272	0,695
	Not Have	108	2,72	0,502			
1. Learning-Teaching Process-Oriented	Have	166	2,76	0,607	0,038	271	0,970
	Not Have	108	2,75	0,558			
2. Profession-Oriented	Have	166	2,45	0,624	-0,986	271	0,325
	Not Have	108	2,53	0,627			
3. Technical-Issue-Oriented	Have	166	2,96	0,640	0,259	271	0,796
	Not Have	108	2,94	0,644			
4. Personal-Oriented	Have	166	2,43	0,632	-0,496	271	0,621
	Not Have	108	2,47	0,635			
5. Social-Oriented	Have	166	2,85	0,693	-1,053	271	0,293
	Not Have	108	2,93	0,651			

As seen in Table 8, the general technostress levels of the participants [$t(272)=-0.393$; $p>0.05$] and the scores related to the technostress sub-dimensions did not show a statistically significant difference based on the variable of having technological education ($p>0.05$).

Table 9 shows the differentiation of the participants' technostress levels based on having personal computer availability variable:

TABLE 9. T-test Results for Independent Samples Regarding the Differentiation of Technostress Levels Based on Having Personal Computer Availability Variable

	COMPUTER	N	x̄	SD	t	df	P
Technostress (Total Score)	Have	160	2,71	0,516	-0,008	272	0,993
	Not Have	114	2,70	0,496			
1. Learning-Teaching Process-Oriented	Have	160	2,76	0,591	0,208	271	0,835
	Not Have	114	2,74	0,583			
2. Profession-Oriented	Have	160	2,48	0,646	-0,109	271	0,913
	Not Have	114	2,49	0,599			
3. Technical-Issue-Oriented	Have	160	2,92	0,632	-1,159	271	0,248
	Not Have	114	3,01	0,652			
4. Personal-Oriented	Have	160	2,43	0,627	-0,359	271	0,720
	Not Have	114	2,46	0,642			
5. Social-Oriented	Have	160	2,93	0,671	1,325	271	0,186
	Not Have	114	2,82	0,683			

As seen in Table 9, the general technostress levels of the participants [$t(272)$=-0.008; p>0.05] and the scores related to the technostress sub-dimensions did not show a statistically significant difference based on the personal computer availability variable (p>0.05).

Table 10 includes the findings of the correlation test conducted to determine the relationships between the technostress levels of the participants and the variables of age and seniority:

TABLE 10. Pearson Correlation Coefficients of the Relationships Between Technostress and Age and Seniority Variables

	1	2	3	4	5	6	7	8
1) Technostress(Total Score)	1							
2) Learning-Teaching Process-Oriented	0,773**	1						
3) Profession-Oriented	0,825**	0,540**	1					
4) Technical-Issue-Oriented	0,811**	0,497**	0,534**	1				
5) Personal-Oriented	0,817**	0,468**	0,684**	0,587**	1			
6) Social-Oriented	0,793**	0,516**	0,541**	0,633**	0,602**	1		
7) Age	0,114	0,047	0,127*	0,111	0,142*	-0,021	1	
8) Seniority	0,090	0,022	0,077	0,090	0,138*	-0,004	0,764**	1

***p<0,01, *p<0,05*

As seen in Table 10, it was determined that there was a low-level, positive, statistically significant relationship between the age variable and the scores of the profession-oriented [r=0,127; p<0,05] and personal-oriented [r=0,142; p<0,05] sub-dimensions of technostress. Accordingly, it can be said that as the age level increases, professional and personal technostress scores of academicians also increase. It has been determined that there is no statistically significant relationship between the age variable and the general technostress level score [r=0,114; p>0,05], and the scores of the learning-teaching process-oriented [r=0,047; p>0,05], technical-issue-oriented [r=0,111; p>0,05] and social-oriented [r=-0,021; p>0,05] sub-dimensions.

It was determined that there was a low-level, positive, statistically significant relationship between the seniority variable and the personal-related sub-dimension score [r=0,138; p<0,05]. Accordingly, it can be inferred that as the seniority of academicians progresses, their technostress scores increase. It has been determined that there is no statistically significant relationship between the variable of seniority and the general technostress level score [r=0,09; p>0,05], and the scores of the learning-teaching process-oriented [r=0,022; p>0,05], profession-oriented [r=0,077; p>0,05], technical issue-oriented [r=0,09; p>0,05] and social-oriented [r=-0,004; p>0,05] sub-dimensions.

However, it was observed that there were positive, statistically significant relationships between technostress and its sub-dimensions.

4. DISCUSSION

In this research, the technostress levels of science faculty members working in universities in the Kyrgyz Republic based on some variables were examined. As a result of the research, it was seen that the general technostress levels of the participants were at a medium level. In support of the research finding, Çoklar et al. (2016) and Gökbulut (2021) revealed that technostress levels were at a medium level in their study with teachers. The results showed that the stress level of academicians and teachers associated with technology use is medium and neither too high nor too low. Medium levels of technostress may indicate that participants experienced some difficulties adjusting to technology use, but it did not seriously affect overall job performance.

Technostress by Gender

General technostress levels and technostress sub-dimensions scores of science faculty members did not show a statistically significant difference based on gender. The results of several studies on the subject obtained from the literature support the study findings. Akman and Durgun (2022), Arslan et al. (2022), Çetin and Bülbül (2017), Çoklar and Bozyiğit (2021), Çoklar et al. (2016), Gökbulut (2021), Khlaif et al. (2023), Le Roux and Botha (2021), Li and Wang (2021), Mokh et al. (2021), Özgür (2020), Yadav and Rahaman (2020) revealed that technostress levels of teachers did not show a significant difference based the gender variable. Gökbulut and Dindaş (2022), who used the same scale as we used in their study, did not find a significant difference between the sub-dimensions of the technostress scale, namely teaching-learning and profession, and the gender variable. However, contrary to the research findings, a significant difference was found in technostress (general) and its technical-issue-oriented, social-oriented, and personal-oriented sub-dimensions based on the gender variable. They found that the technostress levels of female teachers were higher than those of male teachers. Some studies support this result. Abd Aziz et al. (2021), Aktan and Toraman (2022), Çoklar and Şahin (2011), Riedl (2013), Lee et al. (2014), Upadhyaya and Vrinda (2021), Shaukat et al. (2022) revealed that females experienced higher technostress than males. On the contrary, Akgün (2019), Estrada-Muñoz et al. (2020), Ragu-Nathan et al. (2008), and Shu et al. (2011) revealed that the technostress levels of males were significantly different from females. In conclusion, while the result of this research shows that there is no significant difference in technostress levels based on the gender variable, it is possible to say that the relationship between gender and technostress may be complex and diverse as different studies obtain different results.

Technostress by Age

In the age variable, the general technostress levels and technostress sub-dimensions scores of university science faculty members did not show a statistically significant difference. There are contradictory findings in studies conducted on this subject. Akman and Durgun (2022), Maier et al. (2015), Krishnan (2017), Le Roux and Botha (2021) and Wang et al. (2008) stated that there was no significant difference between age groups in terms of technostress levels and sub-dimensions. The studies generally showed a tendency that the technostress levels of teachers did not change depending on their age. However, Çoklar and Şahin (2011), Hauk et al. (2019), Shaukat et al. (2022), Tams et al. (2018), Venkatesh et al. (2012) and Yadav and

Rahaman (2020) revealed that teachers in older age groups experienced more technostress. However, other researchers claim that young people have significantly higher levels of technostress than older people (Hsiao, 2017; Ragu-Nathan et al., 2008; Tarafdar et al., 2011). These findings suggest a potential effect of age on technostress and appear to be incompatible with the findings of other studies. These conflicting results may result from using different research methodologies, sample characteristics, or assessment tools. Additionally, contextual factors such as education systems or technology usage habits may also have an impact. In this context, clearer results are needed by extracting these different results from literature studies and trying to conduct general studies in this direction (Marchiori et al., 2019; Upadhyaya & Vrinda, 2021).

Technostress by Field of Science

In the field of science variable, general technostress levels, profession-oriented, and personal-oriented sub-dimension scores of academicians in science fields differed statistically significantly. However, the scores of the learning-teaching process-oriented, technical-issue-oriented, and social-oriented sub-dimensions did not differ statistically significantly. In the study, it was determined that there was a significant difference between academicians in the field of geography and academicians in the field of informatics based on the personal-related technostress sub-dimension, and there was also a significant difference between academicians in the field of geography and academicians in the field of biology and informatics based on the profession-oriented technostress sub-dimension. The results show that academicians in the field of geography have higher professional and personal technostress levels. As a result, the research revealed that the technostress levels of academicians in the field of geography stand out and that this situation is especially evident in the professional and personal sub-dimensions. The results can be taken into account in support and resource allocation for academics working in these fields.

Technostress by Seniority

In the variable of seniority, the general technostress levels and technostress sub-dimensions scores of science academicians did not show a statistically significant difference. There are studies in the literature that support the findings. Aktan & Toraman (2022); Çoklar et al., (2016); Gökbulut, (2021); Gökbulut & Dindaş (2022); Mokh et al. (2021); Yadav & Rahaman (2020) revealed that there was no significant difference between technostress levels and professional seniorities of teachers, that was, seniority did not affect the technostress level. However, Marchiori et al. (2019) and Penado Abilleira et al. (2021) found that techno-anxiety levels differ depending on the year of seniority. They found that older people are exposed to technostress more frequently than younger people. This result does not support the findings of this research. These conflicting findings highlight the complexity of technostress and the difficulty of context-free generalizations. More comprehensive and multi-perspective research is needed to understand technostress and evaluate its effects.

Technostress by Technological Education Level

According to the variable of having technological education, the general technostress levels and technostress sub-dimensions scores of science academicians did not show a statistically significant difference. Considering that technostress is the result of not being able to cope with new computer technologies healthily,

this result is of course unexpected and remarkable. The result of their study by Akman and Durgun (2022) also supports our findings. The results show that there is no statistically significant difference between the technostress levels of academicians with and without technological education associated with their work in science fields. This means that receiving technology education does not significantly affect the technostress levels of academicians or the sub-dimensions of stress. It can also be said that another issue that needs to be taken into consideration here is the quality of the technological education provided.

Technostress by Technological Device Access

According to the variable of having personal computer availability, general technostress levels and scores on technostress subdimensions did not show a statistically significant difference. The result shows that whether individuals have their computers or not does not affect their technostress levels. Therefore, it can be inferred that this variable does not have a statistically significant effect on general technostress levels. Additionally, no studies have been found in the literature that examined the differences in technostress levels of academicians based on having personal computer availability variable.

Relationship Between Age and Technostress

As a result of the research, it was determined that there was no statistically significant relationship between the age variable and the general technostress level score, or the scores of the learning-teaching process-oriented, technical-issue-oriented, and social-oriented sub-dimensions. However, there was a low-level, positive, statistically significant relationship between age and the scores of the profession-oriented and personal-oriented sub-dimensions of technostress. Accordingly, it can be inferred that as academicians' age increases, their professional and personal technostress levels also increase. There is a study that supports this finding. Penado Abilleira, M. et al. (2021) revealed that there was a positive significant relationship between age and the techno-anxiety levels of university faculty members. Hauk et al. (2019) revealed that age was negatively associated with technology-related stress. The link between age and technology-related strain is explained by behavioral disengagement, which older workers use less than younger workers. In this context, age may not affect the general technostress level of academicians, but as age increases, there is an increase in professional and personal technostress levels. This may indicate that cumulative experiences over time, professional responsibilities, and the use of personal resources may have an impact on certain subdimensions of technostress.

Relationship Between Seniority and Technostress

In the study, it was determined that there was a low-level, positive, statistically significant relationship between the seniority variable and the personal-oriented sub-dimension score. Accordingly, it can be inferred that as the year of seniority progresses, academicians' technostress scores also increase. It has been determined that there is no statistically significant relationship between the variable of seniority and the general technostress level score, and the scores of the learning-teaching process-oriented, profession-oriented, technical issue-oriented, and social-oriented sub-dimensions. Penado Abilleira M. et al. (2021) revealed that

there was a positive significant relationship between seniority and the techno-anxiety levels of university faculty members. Marchiori et al. (2019) discussed the positive relationship between years of professional experience in the public sector and technostress. In general, these findings reveal that seniority has certain effects on the technostress levels of academicians, but these effects vary based on sub-dimensions.

5. CONCLUSIONS

In conclusion, technostress is a crucial issue that needs to be further investigated in academic life. It is related to many key issues such as job satisfaction, performance, productivity, and burnout. Studies on the technostress levels of faculty members will help identify technology-related challenges specific to them and develop solutions to these challenges, develop strategies to increase technology integration in education, program development studies for teacher training, and help universities and other educational institutions develop their strategies regarding the use of technology.

5.1. Limitations and future lines of research

Considering the present pace of development of technology, future studies should conduct repeated studies on a larger sample within the stipulated time limits, covering all scientific fields, and also studies on variables such as job satisfaction, job stress, burnout, intention to quit, job performance, and managerial support. It is thought that it would be useful to carry out longitudinal or experimental designs to better describe the causal connections between these variables.

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7. REFERENCES

Abd Aziz, N., Awang Kader, M., & Ab Halim, R. (2021). The impact of technostress on student satisfaction and performance expectancy. *Asian Journal Of University Education*, *17*(4), 538-552. https://doi.org/10.24191/ajue.v17i4.16466

Akgün, F. (2019). Öğretim elemanlarının bilgi ve iletişim teknolojilerine yönelik kabulleri ve teknostres algıları arasındaki ilişkinin incelenmesi [Investigation of the relationship between ınformation technology acceptance and perceived technostress levels in academic staff]. *Eğitim Bilimleri Araştırmaları Dergisi*, *9*(2), 40-66. https://doi.org/10.22521/jesr.2019.92.1

Akman, E. & Durgun, B. (2022). Öğretmenlerin mesleki motivasyon ve teknostres düzeylerinin incelenmesi [Examination of teachers' professional motivation and technostress levels]. *Fırat* Üniversitesi *Sosyal Bilimler Dergisi*, *32*(2), 487-500. https://doi.org/10.18069/firatsbed.1025152

Aktan, O., & Toraman, Ç. (2022). The relationship between technostress levels and job satisfaction of Teachers within the COVID-19 period. *Education and Information Technologies*, *27*(7), 10429-10453. https://doi.org/10.1007/s10639-022-11027-2

Al-Ansari, M. A., & Alshare, K. (2019). The impact of technostress components on the employee satisfaction and perceived

performance: the case of Qatar. *Journal of Global Information Management (JGIM), 27*(3), 65-86. https://doi.org/10.4018/JGIM.2019070104

Araoz, E. G. E., Quispe-Aquise, J., Huamani-Mallgui, A. Y., Salas-Tincusi, E., Mamani-Calcina, B., & Jara-Rodríguez, F. (2023). Exploring the relationship between technostress and psychological well-being in basic education teachers: A cross-sectional study. *Journal of Law and Sustainable Development*, *11*(2), 442-456. https://doi.org/10.55908/sdgs.v11i2.442

Arslan, H., Şahin, Y. L., Ferhan Odabaşı, H., & Okur, M. R. (2022). An investigation of change in teachers' technostress levels before and after the COVID-19 outbreak. *Educational Media International*, *59*(2), 95-111. https://doi.org/10.1080/09523987.2022.2101202

Ayyagari, R., Grover, V. & Purvis, R. (2011). Technostress: Technological antecedents and implications. *MIS Quarterly*, *35*(4), 831-858. https://doi.org/10.2307/41409963

Brillhart, P. E. (2004). Technostress in the workplace: managing stress in the electronic workplace. *Journal of American Academy of Business*, 5(1/2), 302-307.

Brod, C. (1984). *Technostress: The human cost of the computer revolution*. Addison-Wesley.

Büyüköztürk, Ş. (2021). *Sosyal bilimler için veri analizi el kitabı [Manual of data analysis for social sciences]* (21. Baskı). Pegem Akademi.

Chiappetta, M. (2017). The Technostress: Definition, symptoms and risk prevention. *Senses and Sciences*, *4*(1), 358-361. https://doi.org/10.14616/sands-2017-1-358361

Clark K. & Kalin S. (1996). Technostressed out? How to cope in the digital age. *Library Journal*, *121*(13), 30-32.

Coppari, N., Bagnoli, L., Codas, G., López, H., Martínez, U., Martínez, L., & Montanía, M. (2018). Validez y confiabilidad del cuestionario de tecnoestrés en estudiantes paraguayos. *Perspectivas en Psicología: Revista de Psicología y Ciencias Afines*, *15*(2), 40-55.

Curcuruto, M., Williams, S., Brondino, M., & Bazzoli, A. (2023). Investigating the impact of occupational technostress and psychological restorativeness of natural spaces on work engagement and work–life balance satisfaction. *International Journal of Environmental Research and Public Health*, *20*(3), 2249. https://doi.org/10.3390/ijerph20032249

Çetin, D., & Bülbül, T. (2017). Okul yöneticilerinin teknostres algıları ile bireysel yenilikçilik özellikleri arasındaki ilişkinin incelenmesi [Investıgatıon of the relatıonshıp between school admınıstrators' technostress perceptıons and theır ınnovatıve features]. *Abant* İzzet *Baysal* Üniversitesi *Eğitim Fakültesi Dergisi*, *17*(3), 1241-1264. https://doi.org/10.17240/aibuefd.2017.17.31178-338821

Çoklar, A. N., & Bozyiğit, R. (2021). Determination of technology attitudes and technostress levels of geography teacher candidates. *International Journal of Geography and Geography Education*, (44), 102-111. https://doi.org/10.32003/igge.933183

Çoklar, A. N., & Şahin, Y. L. (2011). Technostress levels of social network users based on ICTs in Turkey. *European Journal of Social Sciences*, *23*(2), 171-182.

Çoklar, A. N., Efilti, E., & Sahin, L. (2017). Defining teachers' technostress levels: A scale development. *Journal of Education and Practice*, *8*(21), 28-41.

Çoklar, A. N., Efilti, E., Sahin, Y. L., & Akçay, A. (2016). Investigation of techno-stress levels of teachers who were included in technology integration processes. *The Turkish Online Journal of Educational Technology*, Special Issue for INTE-2016, 1331-1339.

Efilti, E. & Zhumgalbekov, A. (2023). Adaptatıon of the scale «Determınatıon of the technostress level of teachers» into the Kyrgyz language: Validity and reliability study. Известия вузов Кыргызстана, (1), 113-117. https://doi.org/10.26104/IVK.2022.45.557

Efilti, E., & Çoklar, A. N. (2019). Teachers' technostress levels as an indicator of their psychological capital levels. *Universal Journal of Educational Research*, *7*(2), 413-421. https://doi.org/10.13189/ujer.2019.070214

Ekiz, D. (2015). *Bilimsel araştırma yöntemleri [Scientific research methods]* (7. Baskı). Anı Yayıncılık.

Erdoğan, E., & Akbaba, B. (2022). Sosyal bilgiler öğretmenlerinin teknostres düzeylerinin yordanmasında cinsiyet, tpab, okul desteği ve mesleki doyumun rolü [The role of gender, TPACK,

school support and job satisfaction in predicting the technostress levels of social studies teachers]. *Eğitim ve Bilim*, *47*(210), 193-215. http://dx.doi.org/10.15390/EB.2022.11183

Estrada-Muñoz, C., Castillo, D., Vega-Muñoz, A., & Boada-Grau, J. (2020). Teacher technostress in the Chilean school system. *International Journal of Environmental Research and Public Health*, *17*(15), 5280. https://doi.org/10.3390/ijerph17155280

Fernández-Fernández, M., Martínez-Navalón, J. G., Gelashvili, V., & Román, C. P. (2023). The impact of teleworking technostress on satisfaction, anxiety, and performance. *Heliyon*, *9*(6), e17201 https://doi.org/10.1016/j.heliyon.2023.e17201

Gökbulut, B. & Dindaş, S. (2022). Öğretmenlerin mesleki tükenmişlik ve teknostres düzeylerinin incelenmesi [Investigation of professional burnout and technostress levels of teachers]. *International Journal of Eurasia Social Sciences (IJOESS), 13*(47), 42-59. http://dx.doi.org/10.35826/ijoess.3096

Gökbulut, B. (2021). Öğretmenlerin teknostres ve teknopedagojik yeterlikleri arasındaki ilişki [The relationship between teachers' technostress and their techno-pedagogical competence]. *Ahi Evran* Üniversitesi *Kırşehir Eğitim Fakültesi Dergisi*, *22*(1), 472-496.

Hauk, N., Göritz, A. S., & Krumm, S. (2019). The mediating role of coping behavior on the age-technostress relationship: A longitudinal multilevel mediation model. *PloS One*, *14*(3), 1-22. https://doi.org/10.1371/journal.pone.0213349

Hsiao, K. L. (2017). Compulsive mobile application usage and technostress: The role of personality traits. *Online Information Review*, *41*(2), 272–295. https://doi.org/10.1108/OIR-03-2016-0091

Jena, R. K. (2015). Technostress in ICT enabled collaborative learning environment: An empirical study among Indian academician. *Computers in Human Behavior*, (51), 1116-1123. https://doi.org/10.1016/j.chb.2015.03.020

Karasar, N. (2014). *Bilimsel araştırma yöntemi: Kavramlar, ilkeler, teknikler [Scientific research method: Concepts, principles, techniques]* (5. Basım). 3A Araştırma Eğitim Danışmanlık.

Khlaif, Z. N., Khalili, F., Affouneh, S., & Tlili, A. (2023). How remote learning during crisis affects technostress levels experienced by academicians. *Education and Information Technologies*, *28*(9), 11075-11100. https://doi.org/10.1007/s10639-023-11651-6

Krishnan, S. (2017). Personality and espoused cultural differences in technostress creators. *Computers in Human Behavior*, (66), 154–167. https://doi.org/10.1016/j.chb.2016.09.039

La Torre, G., De Leonardis, V., & Chiappetta, M. (2020). Technostress: how does it affect the productivity and life of an individual? Results of an observational study. *Public Health*, (189), 60-65. https://doi.org/10.1016/j.puhe.2020.09.013

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Sage publications. https://doi.org/10.4135/9781412963947

Le Roux, D.J., & Botha, P.A. (2021). Investigating the impact of technostress on productivity and overall life satisfaction of managers working at a South African ferrochrome smelting company. *SA Journal of Human Resource Management*, *19*(0), a1649. https://doi.org/10.4102/sajhrm.v19i0.1649

Lee, S., Lee, S., & Suh, Y. (2016). Technostress from mobile communication and its impact on quality of life and productivity. *Total Quality Management*, *27*(7), 775-790. https://doi.org/10.1080/14783363.2016.1187998

Lee, Y. K., Chang, C. T., Lin, Y., & Cheng, Z. H. (2014). The dark side of smartphone usage: Psychological traits, compulsive behavior, and technostress. *Computers in Human Behavior*, (31), 373-383. https://doi.org/10.1016/j.chb.2013.10.047

Li, L., & Wang, X. (2021). Technostress inhibitors and creators and their impacts on university teachers' work performance in higher education. *Cognition, Technology & Work*, *23*(2), 315-330. https://doi.org/10.1007/s10111-020-00625-0

Maier, C., Laumer, S., & Eckhardt, A. (2015). Information technology as a daily stressor: Pinning down the causes of burnout. *Journal of Business Economics*, *85*(4), 349-387. https://doi.org/10.1007/s11573-014-0759-8

Marchiori, D. M., Mainardes, E. W., & Rodrigues, R. G. (2019). Do individual characteristics influence the types of technostress reported by workers? *International Journal of Human–Computer Interaction*, *35*(3), 218-230. https://doi.org/10.1080/10447318.2018.1449713

Mokh, A. J. A., Shayeb, S. J., Badah, A., Ismail, I. A., Ahmed, Y., Dawoud, L. K., & Ayoub, H. E. (2021). Levels of technostress resulting from online learning among language teachers in Palestine during the Covid-19 pandemic. *American*

Journal of Educational Research, *9*(5), 243-254. https://doi.org/10.12691/education-9-5-1

Özgür, H. (2020). Relationships between teachers' technostress, technological pedagogical content knowledge (TPACK), school support and demographic variables: A structural equation modeling. *Computers in Human Behavior*, (112). https://doi.org/10.1016/j.chb.2020.106468

Pallant, J. (2017). *SPSS kullanma kılavuzu*. (B. A. Sibel Balcı, Çev.) Anı Yayıncılık.

Penado Abilleira, M., Rodicio-García, M. L., Ríos-de Deus, M. P., & Mosquera-González, M. J. (2021). Technostress in Spanish university teachers during the COVID-19 pandemic. *Frontiers in Psychology*, (12), 1-11. https://doi.org/10.3389/fpsyg.2021.617650

Ragu-Nathan, T. S., Tarafdar, M., Ragu-Nathan, B. S., & Qiang, T. (2008). The consequences of technostress for end users in organizations: Conceptual development and empirical validation. *Information Systems Research, 19*(4), 417-433. https://doi.org/10.1287/isre.1070.0165

Ranathunga, W. D. A. D., & Rathnakara, K. A. K. S. (2022). Impact of techno-stress on job satisfaction of teachers in government schools in Sri Lanka: Evidence from Kurunegala Educational Zone. *Sri Lankan Journal of Human Resource Management*, *12*(1), 16-38. http://dx.doi.org/10.4038/sljhrm.v12i1.5678

Riedl, R. (2013). On the biology of technostress: Literature review and research agenda. *The DATABASE for Advances in Information Systems*, *44*(1), 18-55. https://doi.org/10.1145/2436239.2436242

Rodriguez-Barboza, J. R. (2023). Exploring technostress effects on job performance of higher education Peruvian English teachers. *American Journal of Education and Technology*, *2*(3), 69-75. https://doi.org/10.54536/ajet.v2i3.1803

Salanova, M., Llorens, S., & Ventura, M. (2011). *Tecnoestrés [Technostress]*. Síntesis.

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education*, (128), 13-35. https://doi.org/10.1016/j.compedu.2018.09.009

Sharma, S., & Gupta, B. (2023). Investigating the role of technostress, cognitive appraisal and coping strategies on students' learning performance in higher education: a multidimensional transactional theory of stress approach. *Information Technology & People*, *36*(2), 626-660. https://doi.org/10.1108/ITP-06-2021-0505

Shaukat, S., Bendixen, L. D., & Ayub, N. (2022). The impact of technostress on teacher educators' work–family conflict and life satisfaction while working remotely during COVID-19 in Pakistan. *Education Sciences*, *12*(9), 616. https://doi.org/10.3390/educsci12090616

Shu, Q., Tu, Q., & Wang, K. (2011). The impact of computer self-efficacy and technology dependence on computer-related technostress: A social cognitive theory perspective. *International Journal of Human-Computer Interaction*, *27*(10), 923-939. https://doi.org/10.1080/10447318.2011.555313

Singh, P., Bala, H., Dey, B.L. & Filieri, R. (2022). Enforced remote working: the impact of digital platform-induced stress and remote working experience on technology exhaustion and subjective wellbeing. *Journal of Business Research,* 151, 269-286. https://doi.org/10.1016/j.jbusres.2022.07.002

Solís, P., Lago-Urbano, R., & Real Castelao, S. (2023). Factors that impact the relationship between perceived organizational support and technostress in teachers. *Behavioral Sciences*, *13*(5), 364. https://doi.org/10.3390/bs13050364

Tabachnick, B. G. & Fidell, L. S. (2013). *Using multivariate statistics* (6th Edition). Allyn and Bacon.

Tams, S., Thatcher, J. B., & Grover, V. (2018). Concentration, competence, confidence, and capture: An experimental study of age, interruption-based technostress, and task performance. *Journal of the Association for Information Systems*, *19*(9), 2.

Tarafdar, M., Tu, Q., Ragu-Nathan, B.S. & Ragu-Nathan, T. (2007). The impact of technostress on role stress and productivity. *Journal of Management Information Systems, 24*(1), 301-328. https://doi.org/10.2753/MIS0742-1222240109

Tarafdar, M., Tu, Q., Ragu-Nathan, T. S., & Ragu-Nathan, B. S. (2011). Crossing to the dark side: Examining creators, outcomes, and inhibitors of technostress. *Communications of the ACM*, *54*(9), 113–120. https://doi.org/10.1145/1995376.1995403

Toraman, Ç. & Aktan, O. (2022). The relationship of academicians with technostress levels and job satisfaction in the COVID-19 process. *International Online Journal of Education and Teaching*, *9*(4), 1695-1726.

Upadhyaya, P., & Vrinda. (2021). Impact of technostress on the academic productivity of university students. *Education and Information Technologies*, *26*(2), 1647-1664. https://doi.org/10.1007/s10639-020-10319-9

Ursavaş, Ö. F., Şahin, S., & McIlroy, D. (2014). Technology acceptance measure for teachers: T-TAM. *Eğitimde Kuram ve Uygulama*, *10*(4), 885-917.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS Quarterly*, *36*(1), 157–178. https://doi.org/10.2307/41410412

Wang, K., Shu, Q., & Tu, Q. (2008). Technostress under different organizational environments: An empirical investigation. *Computers in Human Behavior*, *24*(6), 3002–3013. https://doi.org/10.1016/j.chb.2008.05.007

Weil, M. M., & Rosen, L. D. (1997). *Technostress: Coping with technology, work, home, play.* Wiley.

Wang, Y., Wang, Y., Pan, Z. & Ortega-Martín, J. (2023). The Predicting Role of EFL Students' Achievement Emotions and Technological Self-efficacy in Their Technology Acceptance. *The Asia-Pacific Education Researcher,* 33, 771-782. https://doi.org/10.1007/s40299-023-00750-0

Whelan, E., Golden, W., & Tarafdar, M. (2022). How technostress and self-control of social networking sites affect academic achievement and wellbeing. *Internet Research, 32*(7), 280-306. https://doi.org/10.1108/INTR-06-2021-0394

Yadav, A. & Rahaman, A. (2020). Technostress level of teachers in higher education concerning socio-demographic variables. *Periodic Research, 9*(2), 58-65.

Zhi, R., Wang, Y., & Wang, Y. (2023). The Role of Emotional Intelligence and Self-efficacy in EFL Teachers' Technology Adoption. *The Asia-Pacific Education Researcher, 33,* 845-856. https://doi.org/10.1007/s40299-023-00782-6

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Artificial intelligence technologies and ethics in educational processes: solution suggestions and results

Tecnologías de Inteligencia Artificial y ética en los procesos educativos: sugerencias de solución y resultados

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ABSTRACT

Artificial intelligence is a technology used to imitate the human-like thinking and decision-making abilities of computer systems. This technology enables computers to perform complex tasks such as data analysis, learning, problem solving and decision making. It is used in the field of education as well as in every field. While the use of artificial intelligence in the field of education provides advantages such as providing personalized learning experiences to students, providing teachers with intuition about student performance and developing educational materials, the ethical dimension should not be ignored. Therefore, the aim of this study is to produce solutions to ethical problems in the teaching and evaluation processes of artificial intelligence technologies in education. Qualitative research method was used in this study. It has adopted the phenomenological research approach among qualitative research methods. The concept of phenomenon is also the ethics of artificial intelligence. The working group consists of teachers, educational technologists and academicians. When selecting the working group, it was taken into consideration that there were teachers who use artificial intelligence applications in education and academics and technologists working in this field. Document analysis and focus group interviews were used as data collection tools. Content analysis was performed on the data obtained. According to the results of the study, ethical problems encountered with the use of artificial intelligence in education were identified and solution suggestions were offered.

KEYWORDS Artificial intelligence; artificial intelligence ethics; artificial intelligence in education.

RESUMEN

La inteligencia artificial es una tecnología que se utiliza para imitar el pensamiento humano y las capacidades de toma de decisiones de los sistemas informáticos. Esta tecnología permite a las computadoras realizar tareas complejas como análisis de datos, aprendizaje, resolución de problemas y toma de decisiones. Se utiliza tanto en el campo de la educación como en todos los campos. Si bien el uso de la inteligencia artificial en el campo de la educación brinda ventajas como brindar experiencias de aprendizaje personalizadas a los estudiantes, brindar a los docentes intuición sobre el desempeño de los estudiantes y desarrollar materiales educativos, no se debe ignorar la dimensión ética. Por tanto, el objetivo de este estudio es producir soluciones a problemas éticos en los procesos de enseñanza y evaluación de tecnologías de inteligencia artificial en educación. En este estudio se utilizó el método de investigación cualitativa. Ha adoptado el enfoque de investigación fenomenológico entre los métodos de investigación cualitativos. El concepto de fenómeno es también la ética

de la inteligencia artificial. El grupo de trabajo está formado por profesores, tecnólogos educativos y académicos. Al seleccionar el grupo de trabajo se tuvo en cuenta que existieran docentes que utilizan aplicaciones de inteligencia artificial en educación y académicos y tecnólogos que trabajan en este campo. Se utilizaron análisis de documentos y entrevistas de grupos focales como herramientas de recolección de datos. Se realizó un análisis de contenido de los datos obtenidos. Según los resultados del estudio, se identificaron los problemas éticos encontrados con el uso de la inteligencia artificial en la educación y se ofrecieron sugerencias de solución.

PALABRAS CLAVE Inteligencia artificial; ética de la inteligencia artificial; inteligencia artificial en la educación.

1. INTRODUCTION

Artificial intelligence is a term that we frequently encounter today with the rapid advancement of technology and digitalization. However, this concept was first introduced in 1950 with the question “Can machines think?” (Anyoha, 2017). Nabiyev & Erümit (2020) defined artificial intelligence as the ability of a computer-controlled device to perform tasks in a human-like manner. This ability is used not only by private and state institutions, but also in higher education institutions. The applications of artificial intelligence in higher education are increasing day by day and have attracted even more attention in the last few years. For example, the 2018 Horizon report stated that artificial intelligence applications in educational technologies are important developments (Educause, 2018). According to the 2023 Horizon report, AI is widely used in education for mundane and repetitive tasks (Educause, 2023). The recent breakthroughs in AI technology, particularly in the realm of generative AI, have opened up new possibilities for enhancing educational processes and outcomes. Researchers have highlighted the enormous potential of AI-powered technologies in areas such as collaborative, immersive, affective, and exploratory learning (Olga et al., 2023). The incorporation of AI tools into the education sector has been explored in a variety of contexts ranging from curriculum development and instructional strategies to educational administration and student assessment (Alzahrani, 2022; Chen et al., 2020; Zhu, 2021).

Recently, there has been increasing research on how AI applications can be used across the learner lifecycle to explore pedagogical opportunities (Zawacki-Richter et. al., 2019). The use of AI helps learners understand the important factors behind each engagement or changes in their performance. This is thanks to AI’s ability to not only analyze large datasets but also to correlate between different data sources, helping to identify areas where real-time interventions or additional supports are needed. In this way, AI creates a tailored or individualized learning experience for each student, enabling them to understand and develop their strengths, weaknesses, abilities and challenges (Duggan, 2020). Artificial intelligence is used to personalize learning methods by taking into account students’ strengths, weaknesses, abilities and academic problems. This technology also helps educators to develop personalized learning strategies and analyze both qualitative and quantitative data. Furthermore, artificial intelligence is being used to improve the quality of distance education and deliver personalized educational programs to students to ensure effective teaching (Duggan, 2020).

Artificial intelligence aims to meet the needs of each student by adapting learning environments according to individual requirements (Harry, 2023). Artificial intelligence systems that analyze students’ learning

styles, speeds and needs offer a more effective learning process by personalizing the learning experience (Tiwari, 2023). In addition, AI in education offers new opportunities to enrich students' online learning experiences with adaptive learning materials and metacognitive cues (Tapalova & Zhiyenbayeva, 2022). The incorporation of AI tools into the education sector has been explored in a variety of contexts ranging from curriculum development and instructional strategies to educational administration and student assessment (Alzahrani, 2022; Chen et al., 2020; Zhu, 2021). One of the main benefits of AI in education is its ability to deliver personalized and adaptive learning experiences tailored to the unique needs and learning styles of individual students. By analyzing student data and learning patterns, AI-powered systems can provide targeted guidance, feedback and content recommendations, thus allowing students to progress at their own pace and maximize their learning potential. In addition, AI can play an important role in facilitating administrative tasks such as planning, resource management and grading, freeing up educators' time and resources to focus on more meaningful and effective aspects of the teaching and learning process (Mello et al, 2023; Islam, 2023). Overall, AI has the potential to improve teaching and learning outcomes in education. Especially considering the goals of ensuring equality of opportunity in education and ensuring that everyone benefits from education, it is thought that the use of artificial intelligence technologies at different educational levels and dimensions may be beneficial. According to the 2020 report of the UNESCO Institute for Information Technologies in Education (Duggan, 2020), there are some challenges and concerns about the use of AI in education. Among these concerns, issues related to the privacy, protection and use of the data used by AI are important. It is also noted that ethical issues such as racism and gender discrimination may arise in relation to the use of AI technologies.

There has been a huge increase in scientific research on artificial intelligence technologies. Between 2013 and 2016 alone, the number of scientific articles on AI technologies has increased sixfold (Evans & Gawer, 2016). These studies generally focus on the application of existing AI technologies, proposing and/or developing new AI models (e.g., intelligent tutoring systems), or the potential benefits of AI such as profiling and prediction capabilities, assessment and evaluation, adaptive and personalized learning environments (Baz & Denizer, 2018; Zawacki-Richter et al., 2019). This paradigm shift in educational strategies has been explored in depth by various researchers, who have investigated the implications and possibilities of integrating generative AI into educational settings. However, as with any technological advancement, the adoption of generative AI in education also raises ethical considerations and the need for a comprehensive research agenda to address the challenges and opportunities it presents (Olga et al., 2023). In addition to all these fields of study, the ethical dimension also needs to be studied. Solutions need to be produced for each problem identified in the ethical field. A study was designed to create an ethical framework to make a distinction when evaluating artificial intelligence capabilities. This study identified five main challenges such as perception of equity, data privacy, moral agency, moral incompetence and bias towards data. Therefore, it is crucial for universities, one of society's most influential institutions, to develop AI systems and secure new applications within an ethical framework to alleviate legitimate concerns.

It is observed that ethical rules initially focused primarily on the behavior of humans using technology. Today, however, it is also necessary to discuss ethical behavior from the perspective of machines and to examine the decisions and actions that machines take autonomously (Müller, 2020). AI ethics actually functions as a tool for the protection of privacy. Law, which is a positive science with rules and principles

that regulate existing situations, should create the necessary infrastructure for issues that may cause security concerns and ethical concerns in society. Binns (2018) aimed to minimise the negative effects of these systems on users by addressing the issues of transparency and accountability in the decision-making processes of AI systems. Similarly, Floridi and Cowls (2019) identified the basic principles of AI ethics, focusing on issues such as human rights, justice, responsibility and privacy. Furthermore, Whittlestone et al. (2019) provided practical guidelines to promote the ethical use of AI applications. In recent years, Crawford (2021) has discussed how AI can reproduce social inequalities and what policies should be developed to prevent this. In this context, studies on the ethics of AI offer important contributions towards ensuring the responsible and fair use of technology. In this context, studies on the ethics of AI make important contributions towards ensuring the responsible and just use of technology. The contribution of this study to the literature is that it provides an in-depth understanding in the field of educational technologies and AI ethics, providing an important reference point for research at the intersection of these two fields. A detailed consideration of the ethical dimensions of AI applications in education will enable a more responsible and effective use of these technologies. Furthermore, such a study will raise awareness among policy makers and educators to promote innovative and ethical practices in education. Therefore, the aim of this study is to generate solutions for ethical problems in the teaching and evaluation processes of artificial intelligence technologies in education. In line with this purpose, answers to the following sub-questions were sought:

1. What are the ethical problems in educational processes related to artificial intelligence technologies?

2. What are the solutions to the ethical problems that arise in the use of artificial intelligence technologies in educational programs?

2. MATERIAL AND METHOD

In this section, information on the research model, study group, data collection tools, data collection process and analysis are given.

2.1. Research Design

Qualitative research method was used in this study. Qualitative research method is a type of research that relies on qualitative data collection to understand, explain, or clarify a particular topic. Qualitative research is often used to understand complex issues that require in-depth analysis and explanations (Creswell, 2016). Qualitative research is a method that is in the process of questioning and interpreting a unique problem and understanding the form of this problem in its natural environment (Baltacı, 2017). Methods frequently used in qualitative research include observation, interview, document analysis and discourse analysis. Qualitative research focuses on the in-depth examination of human perception and social reality in its natural environment and therefore adopts an inclusive approach that brings together different disciplines (Merriam & Grenier, 2019). This study adopted the phenomenological research approach within qualitative research methods. Phenomenological research is a method that aims to understand and interpret the experiences of individuals. This approach focuses on people's direct expression and understanding of their experiences (Güçlü, 2019). The phenomenon concept of this study is artificial intelligence ethics.

2.2. Study Group

Although various sampling methods are used in qualitative research, the sample that can best explain the purpose of the research should generally be selected. Therefore, in qualitative research, the appropriate sample is selected and studied in detail for a long time in order to reach detailed results (Merriam & Grenier, 2019).

For the purpose of this study, criterion sampling, which is a purposive sampling method among various sampling methods, was preferred. Purposive sampling is a method in which the researcher selects a sample by focusing on a specific purpose or problem. An important feature of this sampling is that it includes groups or individuals with certain qualities to better explain the main purpose of the study. Criterion sampling is when the researcher selects a sample based on a specific criterion (Bryman, 2016). The criterion for this study group was determined as the use of artificial intelligence technology in education. The study group consisted of teachers, educational technologists and academicians. Demographic information about the study group is given in Table 1.

TABLE 1. Demographic information about the participants in the study group

CODE	GENDER	AGE	VOCATION	DURATION OF USE
T1	Woman	32	Teacher	3
T2	Male	36	Teacher	4
T3	Male	28	Teacher	4
A1	Male	41	Academician	5
A2	Woman	43	Academician	4
A3	Male	39	Academician	4
ET1	Woman	31	Education Technologist	5
ET2	Woman	33	Education Technologist	4

Table 1 shows the duration of educational technology usage of individuals from different gender, age and occupational groups in the education sector. There are 8 participants in total. Among the female participants there is a teacher (T1) who is 32 years old and an educational technologist (ET1) who is 31 years old, while among the male participants there is a teacher (T3) who is 28 years old and an academic (A2) who is 43 years old. In terms of occupational groups, besides teachers, academics and educational technologists are also represented in the table.

Looking at the duration of using artificial intelligence tools, it is seen that teachers are generally interested in educational technology between 3-4 years. For example, T1 and T2 have been using educational technology for 3 years and T3 for 4 years. Among academicians, the duration of use ranges from 4 years (A2 and A3) to 5 years (A1). Educational technologists, on the other hand, generally use this technology between 4-5 years.

2.3. Data Collection Tools

In qualitative research, data collection tools such as focus group discussions, interviews, observation and document analysis are preferred for content and descriptive analysis (Merriam & Grenier, 2019). In this study, focus group interviews and document analyses were conducted to reveal the solution proposals regarding the phenomenon. Focus group interview is a data collection technique frequently used in qualitative research. Focus group interviewing is used to understand the thoughts, experiences and opinions of participants about a particular topic or topics. Participants in the group discuss around a specific topic or issue identified by a researcher or moderator. The main purpose of this method is to understand group dynamics by enabling participants to share their ideas and experiences. Focus groups usually consist of 6 to 10 people. They are encouraged to interact and exchange ideas (Sullivan & Forrester, 2018). In the focus interview group of this study, there were 8 people in total. For the interviews with the participants, a semi-structured focus interview form was prepared to clarify the phenomenon. The semi-structured focus interview form consists of two dimensions. The first dimension includes the demographic information of the participants, while the second dimension includes the focus interview questions. Focus interview questions consisted of five basic questions. The focus interview questions were prepared with care to be clear and understandable.

Document analysis is a qualitative research method in which a researcher collects information by examining written or printed documents. These documents usually consist of various documents such as reports, letters, journals, books, policy documents, social media posts, and web pages (Güçlü, 2019). The process of scanning the written documents on the subject evaluated within the scope of the research in detail and creating a new structure from this information is referred to as document analysis (Creswell & Creswell, 2017). This analysis method, which is carried out together with the literature review, systematically organizes the researcher's interview records and documents. While this method saves the researcher time, it also facilitates the prioritization of the topics examined, the categorization of data and the creation of new data sets (Baxter & Jack, 2008). In this study, the artificial intelligence policies developed were analyzed by examining the articles published in indexed journals on the subject.

2.4. Data Collection Process and Analysis

With the determination of the participants and data collection tools, the data collection process was initiated. In this process, if the researcher has not based the research problem on a sufficient theoretical framework and has not chosen the appropriate sample and data collection tools, problems arise in solving the research problem (Creswell & Creswell, 2017). The interviews with the participants in the study, all of which were conducted online, lasted an average of 23 minutes. The interview questions are as follows:

1. What are the most prominent ethical problems you have encountered regarding the use of artificial intelligence technologies in educational processes? In which situations do these problems arise?
2. What do you think about the effects of artificial intelligence-based education systems on student privacy and data security? Can you share your concerns and observations on these issues?
3. Do you think that artificial intelligence technologies create problems in terms of justice and equality in education?

4. What steps should be taken to solve the ethical problems arising from artificial intelligence technologies in educational processes? What are your suggestions?
5. Which policies do you think should be developed to ensure the fair and responsible use of artificial intelligence technologies in education?

The data obtained in the data collection step should be verified from different sources in the literature. Therefore, document analysis was conducted by examining the literature. The data collected during the research process were content analyzed. Content analysis is a type of analysis that generally focuses on the main points of the researched topic. This type of analysis uses coding techniques to reveal the basic concepts underlying the data and the relationships between these concepts. In this way, it allows the information in the research process to be presented in a meaningful integrity. In content analysis, the data obtained from interviews and documents are generally analyzed in four stages: (1) coding the data, (2) identifying codes, categories and themes, (3) organizing the codes, categories and themes, and (4) describing and interpreting the results. These stages represent important steps in the process of in-depth analysis and interpretation of data. The data collected during the research process were first coded by content analysis method. The coding process is carried out to ensure that the data are examined and analysed in a systematic way. Each piece of data is coded under themes and categories determined in line with the research questions and the conceptual framework in the literature. After the coding process is completed, the codes obtained are examined, similar codes are brought together and categories are formed. These categories represent the main themes and sub-themes related to the research topic. While determining the themes and categories, the basic concepts underlying the data and the relationships between these concepts are taken into consideration. At this stage, the codes, categories and themes are organised by establishing connections between them. This organisation process allows the data to be presented in a more meaningful and consistent way. In addition, in this process, it is evaluated whether the data are in accordance with the analytical framework and whether they answer the research questions. In the last stage, the findings obtained from the coded and organised data are defined and interpreted. In this process, it is aimed to present the data in a meaningful integrity. The findings obtained are interpreted by comparing them with the existing information in the literature and it is evaluated whether the research questions are answered.

These stages represent important steps in the process of in-depth analysis and interpretation of data in content analysis. Content analysis allows the research data to be analysed systematically and comprehensively, thus increasing the reliability and validity of the research results.

2.5. Validity, Reliability and Ethical Considerations

Throughout the data collection process and analysis of the study, attention was paid to validity and reliability. Because the researcher needs to check the results to be obtained by the researcher in the face of the event or situation handled. In this study, the following were taken into consideration in line with validity and reliability.

- Participants were given detailed information about the purpose and process of the study.
- The data obtained were kept confidential and codes were given to the participants.

- Participation in the study was voluntary.
- The researcher also described the data obtained from the focus group interviews in an unbiased manner.
- All collected data were re-communicated to the participants to check whether they were understood correctly.
- For the validity of the study, the opinions of all participants in the study group were taken into consideration.
- Data were collected from multiple data sources about the same phenomenon.
- This study has limitations such as small sample size and potential self-selection bias. To overcome these limitations, care was taken to increase the number of participants and to represent participants with different demographic characteristics in order to increase the representativeness of the sample. For example, self-selection bias was minimized by using random sampling method in participant selection. In addition, participants from different regions and various socioeconomic levels were contacted to ensure that the study represents a wider population. These measures were implemented as part of efforts to increase the external validity of the study.

3. RESULTS

The first sub-research question of the study is "What are the ethical problems in educational processes related to artificial intelligence technologies?". Content analysis was performed for the data obtained as a result of the interviews and supported by document analysis. The results obtained as a result of the analysis are shown in Table 2.

TABLE 2. Themes and codes related to ethical problems in educational processes related to artificial intelligence technologies

THEMES	CODES	PARTICIPANTS	FREQUENCY
Privacy	Collection of student data	T1, T2, T3, A1, A2, A3, ET1, ET2	8
	Storage of data	T1, T2, T3, A1, A2, A3, ET1, ET2	8
	Data processing	T1, T2, T3, A1, A2, A3, ET1, ET2	8
The problem of prejudice	Demographic factors	T3, A1, A3, ET1, ET2	5
	Unjust outcomes	A1, ET1, ET2	3
Inequality of opportunity in education	Economic problems	T1, T2, T3, A3, ET2	4
	Demographic differences	T1, A1, A2, A3, ET1, ET2	6
Emotional needs	Lack of social interaction	T1, T2, T3, ET2	4
	Empathy	T2, A3, ET1	3
Transparency	Data trading	A1, A2, A3, ET1	4
	Accountability	T1, T3, A1, A2, A3, ET1, ET2	7

According to Table 2, five different themes were obtained regarding the ethical problems in educational processes related to artificial intelligence technologies: "privacy, prejudice problem, inequality of opportunity in education, emotional needs and transparency". When the privacy theme is examined, it is emphasized by all participants that the ethical dimension is important in collecting, storing and processing student data. Because artificial intelligence applications used in education generally collect and process student data. As a result of the focus interviews and document analysis, it was seen that this data includes various information such as students' identity information, learning habits and performances. Therefore, the collection and storage of personal data should comply with relevant laws and ethical standards. It is also important that these data are stored securely and protected against unauthorized access. Looking at the themes of the bias problem, artificial intelligence systems used in education can reflect prejudices. In addition, it is thought that they may reinforce existing inequalities due to various demographic differences. For example, student assessment systems have been found to produce unfair results based on factors such as gender, ethnicity or socioeconomic status. Regarding inequality of opportunity in education, it is seen that the difficulties experienced in accessing technology due to students' economic differences are addressed as an ethical dimension. In addition, it has been determined that artificial intelligence applications can make subjective evaluations due to demographic differences. Because students who do not have access to technology or have limited access to technology cannot fully benefit from artificial intelligence-supported education opportunities. According to the emotional needs theme, teacher-student interaction decreases with the use of artificial intelligence in education. Therefore, it is predicted that human values and empathy may weaken. In terms of transparency, it is thought that the complexity and difficulty of the internal working mechanisms of artificial intelligence systems may lead to transparency and accountability problems in terms of how decisions are made. Some of the views of the participants on the theme of privacy are given below:

> "Collecting, storing and processing student data is an ethical issue of increasing importance, especially in educational institutions. Policies on this should include clear frameworks and specify what should be done." (ET1)

Some of the participants' views on the theme of prejudice are given below:

> "Artificial intelligence of course has demographic information about users. Based on this information, it can present biased results, for example, due to racist or economic inadequacies. This poses an ethical problem." (ET2)

> "Decisions made as a result of demographic diversity can lead to unfair outcomes." (A1)

Some of the views of the participants on the theme of inequality of opportunity in education are given below:

> "Inequality of opportunity in education is one of the problems that come to mind when we talk about technology. This inequality also triggers artificial intelligence ethics. Because socioeconomic problems can affect the decisions taken by artificial intelligence applications." (A3)

Some of the participants' views on the theme of emotional needs are given below:

> "The use of artificial intelligence in education leads to a lack of social interaction because it reduces teacher-student interaction." (T1)

> "There is ultimately an algorithm behind the apps used and it thinks like a machine. Therefore, the ability to empathize is limited. This situation reveals emotional deficiencies." (T2)

Some of the views of the participants on the theme of transparency are given below:

"Data trade is important. Because users should have knowledge and consent about who the collected data will be shared with and how it will be used." (A2)

Based on the quotes, it can be said that there is an increased awareness of important ethical and practical issues related to the use of AI and educational technologies. Participants point out that the collection, storage and processing of student data is an increasing ethical issue. It is important to have clear frameworks and policies that specify what should be done in these processes. In addition, issues such as bias, inequality and emotional needs are among the themes that participants are concerned about. It is emphasized that artificial intelligence can produce biased results and reinforce inequalities by using demographic information. In addition, the issue of transparency and the fact that technology can cause students to experience deficiencies in the emotional context were also addressed. These comments of the participants point to the ethical challenges and issues that need attention in the use of artificial intelligence and educational technologies.

The second sub-research question of the study is "What are the solutions to the ethical problems that arise in the use of artificial intelligence technologies in educational programs? ". Content analysis was performed for the data obtained as a result of the interviews and supported by document analysis. The results obtained as a result of the analysis are shown in Table 3.

TABLE 3. Themes and codes related to the solutions to ethical problems in educational processes related to artificial intelligence technologies

THEMES	CODES	PARTICIPANTS	FREQUENCY
Solution Suggestions for Ethical Problems	Informing students about data usage	T1, T2, T3, A1, A2, A3, ET1, ET2	8
	Establishing transparent policies	A1, A2, A3, ET1, ET2	5
	Use of anonymization methods	A1, A3, ET1, ET2	4
	Awareness raising and awareness raising	T2, T3, A2, A3, ET1, ET2	5
	Humanoid interactions	A1, A2, A3, ET1, ET2	5
	Review of training materials	ET1, ET2	2
	Develop algorithms that do not reflect biases	A2, ET1, ET2	3
	Establishing objective evaluation criteria	T1, T2, T3, A2	4
	State support due to economic differences	T1, T2, T3, A1, A3,	5
	Adopting the principle of inclusion	A1, A2, A3	3
	Transparency about how algorithms make decisions	ET1, ET2, A1	3
	Establishment of ethics committees	A1, A3	2
	Human-centered design	ET1, ET2	2
	Encryption of sensitive data	A1, A2, A3, ET1, ET2	5
	Limiting access to data	A2, A3, ET1, ET2	4
	Safety inspections	A1, ET1, ET2	3

When Table 3 is examined, it is seen that solution suggestions regarding the ethical problems in the educational processes related to artificial intelligence technologies. Based on the collected data, it is thought that it should be clearly stated how the data collected from the students will be used and for what purposes the data will be analyzed. In addition to informing them how the data will be used, their consent should also be obtained. The ethical suggestion for the topic of data trade was that transparent policies should be developed about with whom the data will be shared. In this regard, it is emphasized that students should have the right to approve and reject data sharing. Anonymization of student data, in other words, hiding individual identity information, is important for data privacy. Both teachers and students should be made aware of the use of artificial intelligence applications. Because with the creation of awareness about data privacy, it allows users to know their rights and make healthy decisions. Artificial intelligence applications should also simulate empathy. Because it is important for applications to interact with students in a human-like way. While an AI-supported learning assistant supports students, it is thought to be important to pay attention to their emotional needs. Educational materials should be reviewed for the accuracy of the information they contain. Because false information and possible unethical information should be corrected in the process. Training data should be diversified to reduce the risk of bias in algorithms. In addition, the algorithms produced should be improved and updated. Identifying economically inadequate students and supporting them by the state are also among the ethical dimensions. In order to reduce the subjective evaluations caused by demographic differences in artificial intelligence applications, the principle of inclusiveness should be taken into consideration. There should be transparency regarding the internal working mechanisms of artificial intelligence applications. It should be made clear to users about how the algorithms used make decisions. It is emphasized that artificial intelligence ethics committees should be established in educational institutions. Human-centered design can be associated with empathy. Because it comes to the fore that technology should have a human-centered design in order to prevent the use of artificial intelligence from weakening emotional and human relations. It is also important to conduct data audits at regular intervals, back up, and create data recovery plans. However, authorization of data access is also among the important issues. Necessary data should be identified and these data should be encrypted. Some of the views of the participants on the theme of solution suggestions for ethical problems are given below:

> "First of all, it is necessary to inform students that their data is being used." (T2)

> "How the data is used, how it is presented and with whom it is shared should be stated transparently and policies should be established in this regard." (A1)

> "Students' data must be anonymized. This method is ethically important." (A3)

> "Awareness trainings about data privacy should be organized for teachers, students and administrators. Because if users know and are aware of what is being done with their data, they can make the right decisions." (A2)

> "Technology should be able to empathize with students and offer a human-like interaction." (ET1)

> "Objective evaluation criteria should be included in artificial intelligence applications in order to eliminate subjective evaluation processes. Thus, measures can be taken against biased results." (A2)

> "Artificial intelligence committees must be established in every educational institution. Because these applications are increasingly taking place in the education sector. Therefore, these committees should investigate and study every aspect of artificial intelligence and guide other stakeholders." (A3)

"It should be determined which data is important and confidential. Accordingly, sensitive data should be encrypted." (ET2)

"In addition to encrypting data, access to it should also be limited. Not everyone should have access to every data." (A3)

These statements of the participants show the awareness of the participants who have thought deeply about the use of artificial intelligence and data in the education sector and suggest various measures. First of all, the importance of informing students that their data is being used and transparently stating how this data is used and with whom it is shared is emphasized. Data privacy and anonymization are also among the prominent ethical issues in this process. It is also stated that awareness trainings on data privacy and ethical use should be organized and objective evaluation criteria should be used in artificial intelligence applications. In addition to these measures, technical steps such as the establishment of AI committees in each educational institution and encryption of sensitive data are also suggested.

4. DISCUSSION

The use of artificial intelligence in the field of education is rapidly becoming widespread. The use of artificial intelligence technologies in educational processes raises various ethical problems. The research conducted by Regan and Jesse (2018) emphasizes that artificial intelligence systems in education will bring some ethical concerns such as privacy when compromises are made in the use of data through recommender systems. The statement in the OECD (2021) report proves that ethical concerns are not unwarranted. "For AI in education, as children are used by commercial developers to test their AI technologies, it is important to design and implement robust ethical guidelines and avoid any "ethical washing" (OECD 2021).

Among the ethical problems of this study, confidentiality, the problem of bias, inequality of opportunity in education, emotional needs and transparency stand out. Research and analysis emphasize that the ethical dimension is important in the processes of collecting, storing and processing student data. Also prominent are confidentiality, the problem of prejudice, inequality of opportunity in education, emotional needs and transparency. Research and analysis show that various suggestions can be developed to solve these problems.

Within the scope of solution suggestions, first of all, data privacy and security problems should be emphasized. It is important to comply with relevant laws and ethical standards in the collection and storage of student data and to ensure data security. In addition, the principle of transparency and accountability should be adopted in data use and analysis processes. To address these ethical concerns, it is important to implement strategies such as transparency and accountability in the development and use of AI systems in education. Another way to address the ethical concerns is through comprehensive training and education for teachers and students on the ethical implications of AI in education. Artificial intelligence should stay away from biased data. This result is in line with Kalayci Onac et al. (2021) who concluded that decisions about the use of AI in the educational process should respect students' rights, privacy, and safety and should not discriminate against them. Anonymizing student data, informing users about data sharing and obtaining their consent also support an ethical approach. Improving the empathy ability of artificial intelligence applications and emphasizing human-centered design will also ensure that emotional needs are taken into consideration. In addition, steps such as the establishment of AI ethics committees in educational institutions, regular data audits and authorization of data access will also contribute to the solution

of ethical problems. All stakeholders should be made aware of this issue. Ma & Jiang (2023) emphasize that informative activities should be organized regularly to raise awareness and educate educators and students about the use of artificial intelligence.

To combat the problem of bias, artificial intelligence algorithms need to be diversified and improved. It is important that algorithms are designed to reduce demographic differences and prejudices. According to Ma & Jiang (2023), the development and supervision of algorithms is important to ensure the ethical use of artificial intelligence. In addition, reviewing the content of educational materials and correcting unethical information also supports this process. Regarding inequality of opportunity in education, problems in access to technology should be addressed. Students who are in economically difficult situations should be supported and should benefit equally from artificial intelligence technologies. In addition, it is important that AI applications also focus on emotional needs and improve human-machine interaction. Williamson & Eynon (2020) found that even if detecting, responding to, and modifying student emotions with AI systems improves learning outcomes, there are critical concerns about how exactly the impact is detected, what the impact is on future learning, educational decisions, and even whether such an application on mental health is ethical. Finally, there should be transparency about the internal working mechanisms of AI technologies. It should be made clear to users how algorithms make decisions and what impact they have on students. This both increases trust and lays the foundation for an ethical approach.

As a result, a multifaceted and comprehensive approach is required to solve ethical problems related to the use of AI technologies in education. Wang et. al. (2020) argue that policies and regulations related to the use of artificial intelligence need to be determined and implemented. This approach should focus on protecting the privacy of student data, reducing bias, providing equal opportunities, considering emotional needs, and adopting transparency/accountability principles.

5. CONCLUSIONS

In line with the findings, firstly, the collection, storage and processing of student data should be in accordance with the law and ethical standards, and data security should be strictly ensured. Furthermore, the importance of transparency and accountability in data use and analysis processes is emphasised. In addition, users need to understand how algorithms make decisions. It is stated that regular information events should be organised to inform educators and students about the ethical use of AI technology and to raise their awareness. Algorithms should be diversified and improved, and designed in a way to reduce demographic differences and prejudices. In addition, support should be provided to students facing economic difficulties and their emotional needs should be taken into account. Finally, transparency about the inner working mechanisms of AI technologies should be ensured and policies and regulations regarding the use of AI should be determined and implemented. With the implementation of these recommendations, it is aimed to ensure the ethical use of artificial intelligence technology and to create a healthier usage environment in the field of education.

For all these, it is important to take steps in the implementation of educational policies. The emphasis on data privacy and security issues requires educational institutions and decision-makers to fully comply

with relevant legal and ethical standards. In this context, transparency and accountability principles should be adopted in the collection, storage and utilization of student data. Furthermore, the solutions developed for the use of AI systems in education should offer strategies for strengthening and effectively implementing these principles. For example, steps such as the establishment of AI ethics committees in educational institutions, regular data audits and authorization of data access can be taken. It is also important to organize comprehensive training and information programmers for teachers and students on the ethical implications of AI in education. These programmers can focus on human-centered design of AI systems and applications to increase their sensitivity. Similarly, problems in access to technology should be addressed to reduce inequalities of opportunity among students. It is particularly important to provide support to students facing financial difficulties and ensure that they benefit equally from AI technologies. Such practices can help education policies create a framework that promotes the ethical use of AI.

In line with these results, the following suggestions can be made to policy makers and educators:

1. Educational institutions can establish AI Ethics Committees to oversee and promote the ethical use of AI technologies. These committees can strengthen the principles of transparency and accountability in the processes of collecting, storing and processing student data.
2. Regular data audits should be conducted and data access authorisations should be determined during the use of AI systems in education. These steps provide important safeguards to ensure data privacy and security.
3. Regular ethics training programmers for educators and students raise awareness of the ethical implications of AI technologies in education. These programmers can increase the sensitivity of AI systems by emphasizing human-centered design.
4. Support should be provided especially to students facing economic difficulties and they should be enabled to benefit from AI technologies equally. Thus, inequalities of opportunity in education can be reduced.
5. Ensuring transparency of decision-making processes and internal mechanisms of AI systems supports users' trust in these technologies and their ethical use. Policies should encourage this transparency and should be updated when necessary.

Implementing these recommendations can help education policies create a framework that promotes the ethical use of AI technologies. By implementing these steps, policymakers and educators can safeguard important issues such as student privacy, fairness, and equity, and make the most of the potential of AI technologies in education.

5.1. Limitations and future lines of research

In line with the results of this study, more research can be done in the future on how algorithms can be developed and how prejudices can be reduced. It can make artificial intelligence technologies in education more human-oriented. Evaluate how successful educational institutions are in acting in accordance with ethical standards. Research can be conducted on the effectiveness of raising awareness of educators and students about the use of artificial intelligence.

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7. REFERENCES

Alzahrani, A. (2022). A systematic review of artificial intelligence in education in the Arab world. *Amazonia Investiga, 11*(54), 293–305. https://doi.org/10.34069/AI/2022.54.06.28

Anyoha, R. (2017). The history of artificial intelligence. *Science in the News*, 28.

Baltacı, A. (2017). Miles-Huberman model in qualitative data analysis. *Ahi Evran University Journal of Institute of Social Sciences, 3*(1), 1-14.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report, 13*(4), 544-559. https://doi.org/10.46743/2160-3715/2008.1573

Baz, F. Ç. & Denizer, E. (2018, 23-25 November). *An overview of research on the use of artificial intelligence in the field of education in Turkey: a content analysis study.* Cemil Meriç - 10th Social Sciences and Sports Congress, Hatay.

Binns, R. (2018). Fairness in machine learning: Lessons from political philosophy. *Proceedings of the 2018 Conference on Fairness, Accountability, and Transparency, 81,* 149-159.

Bryman, A. (2016). *Social research methods.* Oxford university press.

Chen, L., Chen, P., & Lin, Z. (2020, January 1). Artificial Intelligence in Education: A Review. *Institute of Electrical and Electronics Engineers, 8,* 75264-75278. https://doi.org/10.46793/TIE22.223K

Crawford, K. (2021). *The Atlas of AI: Power, Politics, and the Planetary Costs of Artificial Intelligence.* Yale University Press.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Creswell, J.W. (2016). *Qualitative research methods. Qualitative research and research design according to five approaches.* Ankara: Siyasal Yayın Dağıtım.

Duggan, S. (2020). *AI in Education: Change at the speed of learning*. UNESCO Institute for Information Technologies in Education.

Educause. (2018). *The NMC Horizon Report: 2018 higher education edition*. Educause. https://library.educause.edu/~/media/files/library/2018/8/2018horizonreport.pdf

Educause. (2023). *2023 EDUCAUSE horizon report: teaching and learning edition*. Educause. https://library.educause.edu/-/media/files/library/2023/4/2023hrteachinglearning.pdf

Evans, P. C., & Gawer, A. (2016). *The rise of the platform enterprise: A global survey*. The center for global enterprise.

Floridi, L., & Cowls, J. (2019). A unified framework of five principles for AI in society. *Harvard Data Science Review, 1*(1). https://doi.org/10.1162/99608f92.8cd550d1

Güçlü, İ. (2019). *Qualitative research methods in social sciences*. Nika Publishing House.

Harry, A., 2023, Role of AI in education, *Interdiciplinary Journal and Humanity (INJURITY), 2*(3), 260-268. https://doi.org/10.58631/injurity.v2i3.52

Islam, M. A. (2023). *AI & Blockchain as sustainable teaching and learning tools to cope with the 4IR.* Cornell University.

Kalayci Onac, A., Cetin, M., Sevik, H., Orman, P., Karci, A., & Gonullu Sutcuoglu, G. (2021). Rethinking the campus transportation network in the scope of ecological design principles: case study of Izmir Kâtip Çelebi University Çiğli Campus. *Environmental Science and Pollution Research, 28*(36), 50847-50866. https://doi.org/10.1007/s11356-021-14299-2

Ma, X., & Jiang, C. (2023). On the Ethical Risks of Artificial Intelligence Applications in Education and Its Avoidance Strategies. Journal of Education, Humanities and Social Sciences, 14, 354-359. https://doi.org/10.54097/ehss.v14i.8868

Mello, R. F., Freitas, E. L. S. X., Pereira, F. D., Cabral, L. D. S., Tedesco, P., & Ramalho, G. (2023). *Education in the age of Generative AI: Context and Recent Developments.* Cornell University.

Merriam, S. B., & Grenier, R. S. (Eds.). (2019). *Qualitative research in practice: Examples for discussion and analysis.* John Wiley & Sons.

Müller, V. C. (2020). Ethics of artificial intelligence and robotics. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Stanford University.

Nabiyev, V., and Erümit, A. K., (2020). *Prediction with machine learning*. Pegem.

OECD (2021), OECD Digital Education Outlook 2021: pushing the frontiers with artificial intelligence, blockchain and robots, OECD. https://doi.org/10.1787/589b283f-en

Olga, A., Tzirides., Saini, A. S., Zapata, G. C., Searsmith, D., Cope, B., Kalantzis, M., Castro, V., Kourkoulou, T., Jones, J. H., Silva, R. A. D., Whiting, J., & Kastania, N. P. (2023). *Generative AI: Implications and Applications for Education.* Cornell University.

Regan, P. M., & Jesse, J. (2019). Ethical challenges of edtech, big data and personalized learning: Twenty-first century student sorting and tracking. *Ethics and Information Technology, 21*, 167-179. https://doi.org/10.1007/s10676-018-9492-2

Sullivan, C., & Forrester, M. A. (Eds.). (2018*). Doing qualitative research in psychology: A practical guide*. Sage.

Tapalova, O., & Zhiyenbayeva, N. (2022). Artificial intelligence in education: AIEd for personalized learning pathways. *Electronic Journal of e-Learning, 20*(5), 639-653. https://doi.org/10.34190/ejel.20.5.2597

Tiwari, R. (2023). The integration of AI and machine learning in education and its potential to personalize and improve student learning experiences. *International Journal of Scientific Research in Engineering and Management, 7*(2), 1. https://doi.org/10.55041/IJSREM17645

Wang, Y., Hu, M., Zhou, Y., Li, Q., Yao, N., Zhai, G., & Yang, X. (2020). Unobtrusive and automatic classification of multiple people's abnormal respiratory patterns in real time using deep neural network and depth camera. *IEEE Internet of Things Journal, 7*(9), 8559-8571. https://doi.org/10.1109/JIOT.2020.2991456

Whittlestone, J., Nyrup, R., Alexandrova, A., & Cave, S. (2019). The role and limits of principles in AI ethics: Towards a focus on tensions. *Proceedings of the 2019 AAAI/ACM Conference on AI, Ethics, and Society,* 195-200.

Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology, 45*(3), 223-235. https://doi.org/10.1080/17439884.2020.1798995

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education-where are the educators?. *International Journal of Educational Technology in Higher Education, 16*(1), 1-27. https://doi.org/10.1186/s41239-019-0171-0

Zhu, Y. (2021, June 12). Research on English teaching of professional skilled talents training based on artificial intelligence. IOS Press, 1-12.