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Examination of the Interactive Digital Mathematics Games According to NCTM Standards

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Abstract

This study aimed to examine the interactive digital games that are open to access at the secondary education level on the Education Informatics Network [EIN] platform according to NCTM standards. 20 interactive mathematics games that are open to access on the EIN platform have been reached. Accessed games were analysed descriptively with a code book developed by Joung and Byun (2021) based on the NCTM Content and Process Standards. According to the results of the study, it was determined that the majority of the games are focused on the Numbers and Operations. All of the games targeted fifth and sixth graders, and no games were included for probability domain. Geometry has the highest mean scores for content standards while algebra has the lowest. Games related to geometry, measurement, and numbers exhibit a moderate degree of alignment with the underlying content domains, whereas games centered on data and algebra show a relatively weaker correspondence between the content and the contextual aspects of the game. On the other hand, as for the process standards, algebra has the highest mean scores while geometry and numbers have the lowest mean scores. Highest mean scores for process standards belong to problem solving for data, reasoning and proof for measurement, connections for data and algebra, representations and communication for algebra. Among the process standards, reasoning and proof, and communication were represented with the lowest means for all domains. Considering the results it is advisable to revise digital interactive mathematics games to meet the content and process standards.

Key Words

Educational games • Mathematics education • EIN • NCTM content and process standards

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Introduction

Research on games has revealed that games are not only pleasant time, entertainment, recreation and leisure activity, but also highly effective educational tools (Uğurel & Moralı, 2010). Such educational games can make lessons enternatining and eliminate students' negative attitudes and bias (Koç Deniz, 2019). They can increase the quality of learning by turning learners into active learners while increasing their motivation, thus serving as an effective learning environment (Chizary & Farhangi, 2017; Ibrahim & Jaafar, 2009; Pilten et al., 2017; Song & Zhang, 2008). Games are also used as effective educational tools to improve learning and understanding of complex topics (Chizary & Farhangi, 2017). Despite the existence of various categories of educational games, digital games, including but not limited to puzzles, simulations, and action and adventure games, are among the most extensively employed within the educational context (Connolly et al., 2012).

In the literature, researchers' definitions and classifications of digital games vary (Malone, 1981; Prensky, 2001). For instance, according to Spires (2015), digital games can be defined as multimodal texts, which consist of a combination of communication tools, including static and dynamic images, sound, music, speech, and writing. Samur (2016), on the other hand, defined digital games as "games with certain rules and objectives, played through a hardware (mobile phone, tablet, game console, etc.)". De Freitas (2006) defines digital games as "applications that use the features of video and computer games to create intriguing and immersive learning experiences to achieve specified learning objectives, outcomes and experiences". In an alternative characterization, digital games are delineated as interactive activities imbued with a rewarding framework structured around specific objectives (Vogel et al., 2006). It is evident from these delineations that the definition of digital games is subject to variability contingent upon the specific emphasis placed on distinct features. The concept of digital educational game-based learning, which emerged with the integration of digital games into learning environments, can be defined as the combination of interactive entertainment and formal learning through digital games (Anastasiadis et al., 2018). Digital game-based learning is an important approach to learning due to its promotion of contextualized learning, motivation provision, and encouragement of curiosity (Gee, 2007; Kirriemuir & McFarlane, 2004; Prensky, 2006). Van Eck (2015), emphasizing the connection between digital games and context, defined digital game-based learning as "the use of an existing course, class, or other teaching contexts where the primary objective is learning rather than mere entertainment. It has been stated by many researchers that digital games are effective in the teaching-learning process (Alexiou & Schippers, 2018; Herger, 2014; Prensky, 2001). It is important to use digital learning environments to provide sustainable learning experiences for students who grow up with technology (Gareau & Guo, 2009; Prensky, 2001). Educational digital game-based learning is worthy of preference in learning environments because it provides fun learning (Anastasiadiset al., 2018; Gee, 2003; Prensky, 2001). Within these instructional environments, students engage in the process of realizing, acquiring, utilizing, or applying targeted information while actively participating in digital games (Kim et al., 2009). Additionally, the element of enjoyment exerts a positive influence on students' enthusiasm for learning, thereby enhancing their overall motivation (Alaswad & Nadolny, 2015; Alexiou & Schippers, 2018; Joung & Byun, 2021; Hamari et al., 2016; Landers & Landers, 2014; Peterson, 2010; Prensky, 2001; Ray & Coulter, 2010; Ribeiro, 2019; Spires, 2015). It is also possible to ensure the attention of the students about the information to be learnt through educational digital games and to attract the student's interest

(Alexiou & Schippers, 2018; Deng et al., 2020; Ebner & Holzinger, 2007; Liu & Chu, 2010). It is stated that there is an increase in students' academic achievement thanks to educational digital games that make the learning-teaching process efficient (Acquah & Katz, 2020; Joung & Byun, 2021; Ding et al, 2017; Landrs & Landers, 2014; Tangkui & Keong, 2020; Wang & Chen, 2010; Yüksel, 2019). Research findings substantiate that educational digital games stand out as both a highly favored and efficacious instructional tool within the realm of education (Riopel et al., 2019).

Educational Digital Games in Mathematics Education

The opportunities presented by digital games in the teaching and learning process have spurred their rapid adoption in education (Sykes, 2018). Numerous studies examining the utilization and impact of educational digital games in mathematics learning environments concentrate on the pivotal role of these games in enhancing students' mathematical knowledge and problem-solving skills (Acquah & Katz, 2020; Barros et al., 2020; Bofferding & Hoffman, 2019; Cramer, 2019; Devlin, 2011; Drijvers et al., 2014; Kärki et al., 2021; Lee et al., 2023; Meletiou-Mavrotheris & Prodromou, 2016; Ramani & Siegler, 2011). It can be asserted that digital games hold significance in the realm of mathematics education, particularly in the cultivation of problem-solving skills, which occupies a central role. Students afforded the opportunity to engage with problem situations structured within a captivating and thought-provoking context have demonstrated noteworthy enhancement in their problem-solving capabilities through the utilization of educational digital games (Acquah & Katz, 2020; Dai et al., 2022; Gros, 2007; Hwang et al., 2015; Issa, 2007; Jenkins et al., 2006; White & McCoy, 2019; Spires, 2015; Sun et al., 2022). Furthermore, their dispositions towards problem solving have exhibited a positive transformation as well (Dayo et al., 2021; Dweck, 2015). In addition, educational digital games improve students' mathematical reasoning skills (Bakker et al., 2015; Ke, 2014; Kolovou, & van den Heuvel-Panhuizen, 2010; Olson et al., 2007). One of the significant opportunities that games offer within mathematics learning environments pertains to students' attitudes towards mathematics. Educational digital games have a positive impact on students' attitudes toward mathematics (White & McCoy, 2019). Educational digital games also enable children to use mathematical language as a communication tool in mathematics classrooms (Moyer-Packenham et al., 2019; Umbara et al., 2021). By means of educational digital games, students are exposed to various representations of mathematical knowledge and engage in their utilization (Moyer-Packenham et al., 2019). Within the Turkish context, it can be asserted that one of the foremost resources for educational digital games is the Education Informatics Network.

EIN as an Educational Digital Game Resource in Turkey

Education Informatics Network (EIN), which is an important and official source for educational digital games in Turkey, is a digital platform open to the use of students, parents and teachers within the Ministry of National Education. EIN, which started its publishing life in 2012, has been renewed and enriched with changing needs and has become one of the world's largest learning object warehouses (Tuluk & Akyüz, 2019). The primary goal of the EIN platform is to facilitate the effective utilization of educational materials through information technologies and promote the integration of technology into education. EIN offers reliable and vetted e-content suitable for grade levels and continues to develop by following innovations in education and technology (Üce, 2019). For this purpose,

it provides students with reliable and accurate content suitable for their purposes inside or outside the school (İskender, 2016). When EIN is evaluated in terms of secondary school mathematics teaching, it is seen that there are various contents aiming to provide students with the learning objectives in the secondary school mathematics curriculum. One of these contents is digital games. EIN is a constantly updated platform open to development and change. In this context, it is necessary to examine whether the contents in EIN, especially secondary school mathematics games, have sufficient content. When the research conducted on the EIN platform is examined, it is found that there are studies on the effect of EIN-supported teaching on students' academic achievement, academic self-regulation and basic psychological needs (Haskanlı, 2021). Research endeavors have encompassed investigations into the contents of the EIN through the lens of Bloom's taxonomy (Günbaş & Öztürk, 2022), as well as examinations aligning with the seamless learning principles articulated by Wong and Looi (Poçan & Yaşaroğlu, 2017). Additionally, inquiries have been undertaken to elicit the perspectives of educators regarding EIN activities (Kepceoğlu & Ercan, 2019) and to gather insights from both educators and prospective educators concerning the games available on this platform (Tuluk & Akyüz, 2019). Therefore, when the relevant literature is examined, it can be stated that there are insufficient studies dealing with the game contents of secondary school mathematics course among the EIN platform contents (Günbaş & Öztürk, 2022). Considering that the effective use of games, especially as a cognitive development-oriented educational tool or teaching method, is very important, it is noteworthy to systematically examine game design (Pilten et al., 2017), especially the games on the EIN platform (Günbaş & Öztürk, 2022) for maximum educational benefit. Indeed, digital games can serve as valuable tools for creating efficient learning environments. Nevertheless, attaining such efficiency requires meticulous discernment in the selection of games that exhibit a high degree of alignment with the specified educational objectives and desired learning behaviors (Prensky, 2001). Ensuring that these goals and behaviors align with both the nation's own educational programs and globally recognized common norms and standards is of paramount importance. As a matter of fact, to the extent that countries implement practices in accordance with these norms, they are respected and take their place in international platforms (Umay et al., 2006). The delineation of eight pivotal competencies within the Turkish Qualifications Framework (TQF) as outlined by the Ministry of National Education (MoNE, 2018), and their incorporation into the Mathematics Curriculum in Turkey, underscores the significance attributed to these shared standards within the Turkish educational system. These competencies are deemed essential for students' proficiency in their personal, social, academic, and professional pursuits, both domestically and in the global context. One of the most internationally recognised organisations in mathematics education is the National Council of Teachers of Mathematics [NCTM].

NCTM Standards

Founded in 1920 in the United States, NCTM, the world's largest mathematics organisation (NCTM, 2023, https://www.nctm.org/About/), established the Commission on Standards for School Mathematics in 1986 to help improve the quality of school mathematics (Toumasis, 1997). With the establishment of this commission, NCTM published The Principles and Standards for School Mathematics in 2000, which provides a vision for establishing basic educational guidelines for grades preschool through K12 (Deal & Wismer, 2010). The objectives delineated within the Principles and Standards for School Mathematics, promulgated by the National Council of Teachers of

Mathematics (NCTM) in the year 2000, encompassed the following facets: the formulation of comprehensive and logically interconnected learning goals spanning the entire educational spectrum from preschool to K-12; the provision of a toolset for educators to appraise and gauge the caliber of mathematics curricula; the provision of guidance for the construction of curriculum frameworks, evaluation methods, and educational resources; and the facilitation of dialogues aimed at devising effective strategies for nurturing students' attainment of foundational mathematical comprehension (NCTM, 2000). Therefore, this guiding document highlights the essential components of a high-quality school mathematics programme, provides a common mathematical foundation for learning by all students (NCTM, 2000), and suggests how to achieve and support a mathematically rich school environment (Midgett & Eddins, 2001). Furthermore, the standards outlined in this document define the mathematics that students should understand and apply (Joung & Byun, 2021). The standards are discussed under two headings: process and content standards. The quintet of Content Standards (Numbers and Operations, Algebra, Geometry, Measurement, Data Analysis and Probability) unambiguously delineate the specific domains of mathematical knowledge that students are expected to acquire. In contrast, the quintet of Process Standards (Problem Solving, Reasoning, Probability and Proof, Communication, Connections, Representations) underscore the methodologies and approaches relevant to the acquisition and application of said content knowledge. Research demonstrates that textbooks aligned with NCTM standards enhance students' learning outcomes, boost their mathematical knowledge and skills, and contribute to the professional development of teachers and educational leaders (Alabdulaziz & Higgins, 2021). Similarly, it is stated that NCTM process standards can provide effective challenging mathematics environments for children and develop their higher-order thinking (Stoll, 2015). Based on the results of the research, it can be stated that NCTM process and content standards are very effective in realising the desired mathematics education. Students and teachers will experience the mathematics education envisaged by the NCTM standards only with the support and leadership of school and district administrators because administrators have the opportunity to contribute to the development of mathematics education at many different levels through the implementation of mathematics principles and standards, policies and structures in their schools, the selection of instructional materials, and the support of teachers' professional development (Midget & Eddins, 2001). Therefore, examining the extent to which the content produced and supported by education policy makers in countries is in line with the NCTM standards will give clues as to where they are in terms of achieving the desired mathematics education. There are obviously many aspects of classroom practice, including the content presented and the nature of classroom instruction, that can influence student achievement and be relevant to future policy debates. However, it is clear that evaluating the content used by teachers in the light of NCTM standards represents an important basis for improving mathematics teaching and learning (Alabdulaziz & Higgins, 2021). The studies in the literature focused on the topics of examining digital games from an educational perspective (Gözüm & Kandır, 2021); the effects of digital mathematics games on student performance and attitudes (Cai et al., 2022; Jarrah et al., 2022; Kolovou et al., 2013; Luo et al., 2022; Starkey, 2013; White & McCoy, 2019), mathematical reasoning (Jensen & Scott, 2022), mathematical problem-solving attitudes (Dayo et al., 2021) and problem-solving performance (Sun et al., 2022); examining the design features of digital games (Moyer-Packenham et al., 2020); opinions of teachers and students about digital games (Özata & Coşkuntuncel, 2019; Yong et al., 2016). Two studies were found that examined games according to NCTM standards (Arabacı, 2021; Joung & Byun, 2021). In their research, Joung and Byun (2021)

examined the digital games that were discussed in previous studies and are still accessible according to NCTM standards. Arabacı (2021) examined the games designed by teacher candidates according to NCTM standards. Therefore, there is no study examining the digital games on EIN, which is an important and official source for educational digital games in Turkey, according to NCTM standards. From this vantage point, the primary objective of this investigation is to conduct an analytical assessment of the digital games within the EIN, a significant and officially sanctioned repository for educational digital games established under the auspices of the Turkish Ministry of National Education. This analysis will be conducted with a specific focus on discerning the alignment of these digital games with the content and process standards articulated by the National Council of Teachers of Mathematics (NCTM).

Method

Research Design

This study employs a quantitative research methodology, which focuses on collecting and analyzing numerical data. A case study research design which presents a holistic view of a specific case was used in the present study (Yin, 2016). Given the comprehensive scrutiny of interactive mathematics games within the framework of NCTM standards, the present research employs a corresponding research design.

Research Sample

The games examined were sourced from the Education Informatics Network's website (https://eba.gov.tr). Since this study focuses on evaluating interactive games, only those meeting this criterion were intended to be included. The games were searched for using the keywords of ‘game’ and ‘mathematics’ separately. Later on, the search was filtered according to grade level (5^{th}, 6^{th}, 7^{th} and 8^{th}), lesson (mathematics) and type of the content (games). This selection process resulted in a 20 interactive mathematics games in total. Furthermore, it is noteworthy that one of the games exhibited relevance to multiple learning domains, specifically encompassing both the domains of measurement and geometry. Therefore, a total of 21 coding scores from 20 games were analyzed in this study. Hence 21 coding scores out of 20 games have been analyzed within the study. All the games included were accessible and playable at the time of conducting this study.

Research Instruments and Processes

A codebook developed by Joung and Byun (2021) to examine the interactive mathematics games has been used to collect data. This codebook has been created taking NCTM (2000) content and process standards into consideration to analyze mathematics games. The codebook encompassed a categorization system consisting of two primary domains: Content Standards and Process Standards. The content standards comprise 41 itemsto examine the content of the games in terms of five learning domains, i.e. Number and operation (7 items), Algebra (10 items), Geometry (9 items), Measurement (4 items), and Data analysis and probability (11 items). The process standards include 28 items related to five areas which are Problem Solving (4 items), Reasoning and Proof (6 items), Communication (5 items), Connection (5 items), and Representation (8 items). All the items used a 5-point Likert

scale for coding, i.e. strongly disagree (1), disagree (2), neutral (3), agree (4), and strongly agree (5). While content standards vary across the learning domains, process standards remain the same for all learning domains.

Two coders independently evaluated and scored each of the games on the 5-point Likert scale according to the NCTM content and process standards. The items were scored based on the degree of the evaluator's agreement of the statement. The coding scores for ten chosen games were evaluated in terms of reliability. These scores have been used to calculate the interrater reliability using Cohen's Kappa statistic. To assess reliability, a single game representative of each learning domain was selected, and the coding scores for these five games were subjected to analysis, yielding a Cohen's Kappa statistic value of .88. According to Altman's (1999) classification, it was observed that there was a very good level of agreement between the game coding of two independent evaluators.

Data Analysis

The data recorded in a Microsoft Excel file were analyzed descriptively in the first place. Each of the games was analyzed based on the scores obtained from the coders. Means and graphical representations were presented to picture the characteristics of the games in terms of content and process standards. Mean scores of each category show the degree of alignmentinteractive games to the NCTM content and/or process standards. Means have been evaluated according to the classification of low (1-2.33), medium (2.34-3.67), and high (3.68-5.00) levels of alignment.The subdomains of process standards were analyzed using one-way ANOVA after ensuring that the normality assumptions were met. The data pertaining to all variables under scrutiny in the analysis exhibited normal distribution characteristics, as indicated by the skewness values ranging from 0.16 to 1.43 and kurtosis values ranging from -1.48 to 0.53, in accordance with the guidelines presented by Tabachnick and Fidell (2012).

Results

In this study, 20 different games were examined across grade levels and learning domains. As there is no game related to probability, the findings were presented for geometry, data, algebra, measurement, and numbers. Table 1 presents the distribution of the games.

Table 1.

Distribution of games according to learning domains and grade levels

Grade levels	**5th**	**6th**	**7th**	**8th**	**Total**	
					n	**%**
Geometry	1	-	-	-	1	5
Data	-	1	-	-	1	5
Algebra	-	1	-	-	1	5
Measurement	3	1	-	-	4	19
Numbers	9	5	-	-	14	66
Total	13	8			21	100

Table 1 shows that there are no games prepared for 7th and 8th grades. Most of the games (62%) were created for the fifth grades. The preponderance of the games, constituting 66% of the sample, was developed within the purview of the Numbers learning domain, with measurement learning domain ranking as the subsequent area of

focus. There is only one game for each of the geometry, algebra, and data. The games were further examined in terms of NCTM standards. The mean scores for content and process standards are presented in Table 2.

Table 2

Means of content and process standards across learning domains

	Geometry	**Data**	**Algebra**	**Measurement**	**Numbers**
Content standards	3.10	1.82	1.56	2.63	2.52
Process standards [PS]	1.43	2.04	2.36	1.99	1.51
$PS_{Problem\ solving}$	1.25	3.00	2.25	2.50	1.80
$PS_{Reasoning\ and\ Proof}$	1.33	1.00	1.00	1.67	1.07
$PS_{Connections}$	2.00	3.40	3.40	2.55	1.97
$PS_{Representations}$	1.38	2.00	3.13	1.97	1.60
$PS_{Communication}$	1.20	1.20	1.80	1.45	1.19

Low level Medium level

Table 2 presents that geometry has the highest means scores for content standards while algebra has the lowest. This means that geometry games are highly related with the geometry domain while algebra games lack the connection between the algebra content and the game context. Algebra has the highest means scores for process standards while geometry has the lowest. This observation signifies that geometry games, in their current manifestation, exhibit a deficiency in adhering to the process standards, albeit demonstrating alignment with the content standards. Notably, the process standards, particularly those encompassing connections, record the highest mean scores within the domains of algebra and data. Problem solving has the highest mean scores for data, reasoning and proof has for measurement, representation and communication has for algebra.Numbers and geometry have the lower mean scores for process standards compared with the other domains while they have higher content standards. The least mean score belongs to reasoning and proof for algebra, and data. Given that a score of 1 signifies the lowest ranking, it is apparent that these games exhibit a deficit in terms of content related to reasoning and proof. Figure 1 provides a visual representation of the distribution of mean scores pertaining to both content and process standards across various learning domains.

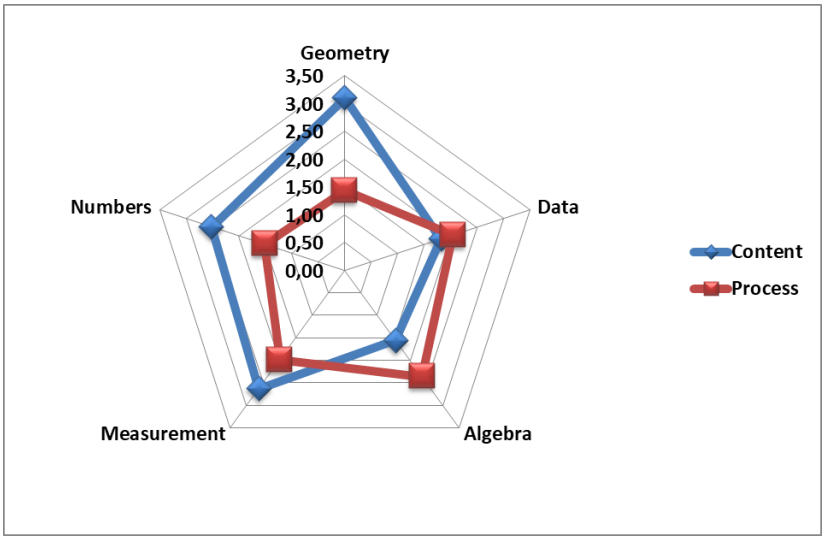

Figure 1. Comparison of content standards across learning domains

As Figure 1 also puts forth visually, geometry, numbers and measurement have the highest mean scores for content standards while algebra and data have the lowest mean scores. Moreover, algebra has the highest means scores for process standards while geometry and numbers have the lowest mean scores.

Figure 2 represents the distribution of the process standards across learning domains.

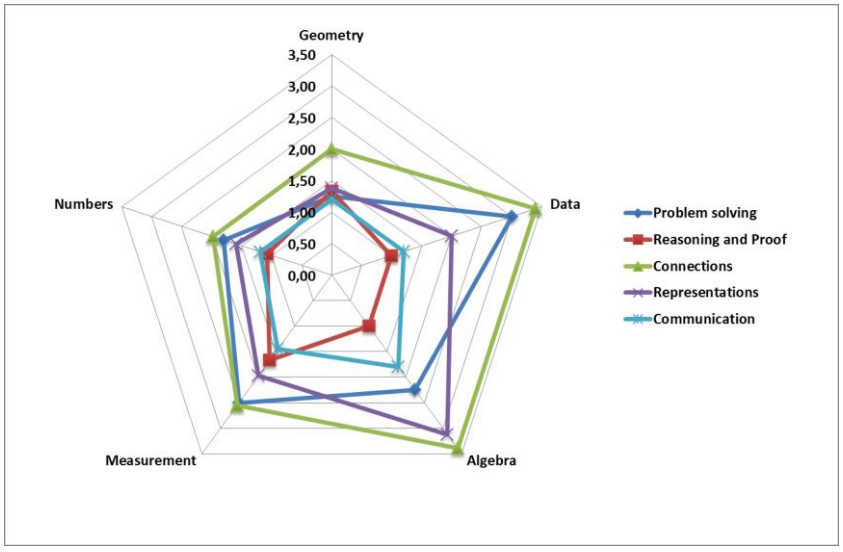

Figure 2. Comparison of process standards across learning domains

According to Figure 2, connection has the highest mean scores across all learning domains while reasoning and proof and communication have the lowest mean scores. This suggests that the games should be improved in terms of these process standards having the lowest mean scores. The comparison of learning domains has also been examined across the process standards, which is shown in Figure 3.

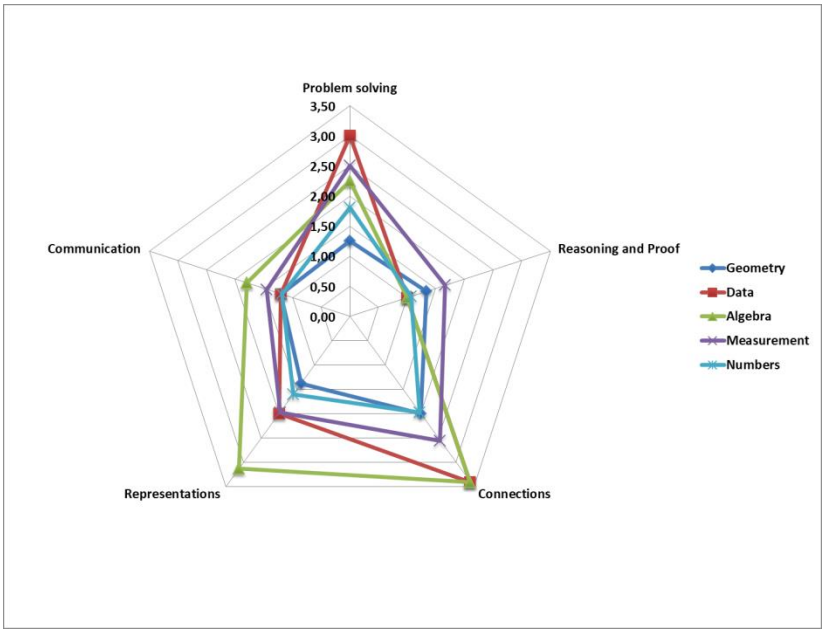

Figure 3. Comparison of learning domains across process standards

Figure 3 illustrates that algebra, data, and measurement have relatively the higher mean scores for process standards compared to the other learning domains. This suggests that the games related to numbers and geometry needs to be improved in terms of process standards.

While there is discernible variability in the process standards across the diverse learning domains, the assessment of distinctions among these process standards necessitated the application of a one-way analysis of variance (ANOVA). The outcomes of the ANOVA analysis are duly presented in Table 3.

Table 3

ANOVA results according to process standards

Subscales	**Source of variances**	**Sum of squares**	**df**	**Mean square**	**F**
Geometry	Between groups	2.09	4	.52	.95
	Within groups	12.75	23	.55	
	Total	14.85	27		
Data	Between groups	22.96	4	5.74	8.25**
	Within groups	16.00	23	.69	
	Total	38.96	27		
Algebra	Between groups	22.80	4	5.70	8.39**
	Within groups	15.62	23	.67	
	Total	38.42	27		
Measurement	Between groups	4.69	4	1.17	8.03**
	Within groups	3.36	23	.14	
	Total	8.06	27		
Numbers	Between groups	3.15	4	.78	6.82**
	Within groups	2.65	23	.11	
	Total	5.81	27		

ANOVA results suggest that there isnot a significant difference on geometry [$F(4, 23) = 0.95$, $p > .05$] according to the process standards. However there is a significant difference on data [$F(4, 23) = 8.25$, $p < .05$], algebra [$F(4, 23) = 8.39$, $p < .05$], measurement [$F(4, 23) = 8.03$, $p < .05$] and numbers [$F(4, 23) = 6.82$, $p < .05$] according to the process standards.

Post hoc comparisons using the Tukey HSD test indicated that the mean score of the problem solving ($M = 2.50$, $SD = 0.35$) was significantly different than reasoning and proof ($M = 1.67$, $SD = 0.20$), and communication ($M = 1.45$, $SD = 0.41$) for measurement. Moreover, the mean score of connections ($M = 2.55$, $SD = 0.41$) was also significantly different than reasoning and proof ($M = 1.67$, $SD = 0.20$) and communication ($M = 1.45$, $SD = 0.41$) for measurement.

A post hoc Tamhane test indicated that the mean score of the problem solving ($M = 3.00$, $SD = 1.15$) was significantly different than reasoning and proof ($M = 1.00$, $SD = 0.00$), and communication ($M = 1.20$, $SD = 0.44$) for data. Moreover, the mean score of connections ($M = 3.40$, $SD = 0.54$) was also significantly different from reasoning and proof ($M = 1.00$, $SD = 0.00$) and communication ($M = 1.20$, $SD = 0.44$) for data.

A further post hoc Tamhane test indicated that the mean score of the representations ($M = 3.13$, $SD = 0.83$) and connections ($M = 3.40$, $SD = 0.89$) was significantly higher than reasoning and proof ($M = 1.00$, $SD = 0.00$) for algebra. Moreover, the mean score of connections ($M = 3.40$, $SD = 0.89$) was also significantly higher than communication ($M = 1.80$, $SD = 1.30$) for algebra.

Another post hoc comparisons using the Tamhane test indicated that the mean score of the problem solving ($M = 1.80$, $SD = 0.35$) was significantly higher than reasoning and proof ($M = 1.07$, $SD = 0.06$) for numbers. Moreover, the mean score of connections ($M = 1.97$, $SD = 0.47$) was also significantly higher than reasoning and proof ($M = 1.07$, $SD = 0.06$) and communication ($M = 1.18$, $SD = 0.28$) for numbers.

Discussion, Conclusion & Suggestions

In the study, 21 interactive digital mathematics games at the secondary school level in EIN were analysed according to NCTM content and process standards. When the analysed games were examined in terms of content standards, it was found that the majority of the games were related to the number and operations learning domain, followed by the measurement learning domain. Furthermore, it has been ascertained that the EIN features only a solitary game each within the realms of geometry, data processing, and algebra learning domains, with a conspicuous absence of games pertaining to the probability domain. This notable disparity in the prevalence of games associated with the numbers and operations learning domain can be attributed to the fact that this domain encompasses the largest number of learning outcomes as stipulated within the secondary school mathematics curriculum (Arabacı, 2021). The fact that there are no games in EIN in the probability learning domain is thought to be due to the fact that there are very few objectives (5) in this learning domain in the curriculum and that these objectives are at the 8th grade level (MoNE, 2018; Arabacı, 2021). These results obtained from the research coincide with the results obtained by Joung and Byun (2019). Out of the 23 digital games examined by the researchers, 15 were related to the numbers and operations content standard, while none of the games met the data analysis and probability content

standard. Another result obtained in the study is that there are no mathematics games at the 7th and 8th grade level in EIN. Parallel to this result, Akkaş Dede (2021) found that technology-supported educational games in Turkey are concentrated at the 5th and 6th grade level in his study of 29 postgraduate theses. In this context, the question that needs to be addressed is 'why there are no games at the 7th and 8th grade level in EIN'. This situation may be attributed to an exam-oriented educational approach. As a matter of fact, studies show that teachers consider it a waste of time to play educational mathematics games for students who are in the preparation stage for exams (Özata & Coşkuntuncel, 2019); therefore, they think that the use of games in mathematics teaching is more suitable for younger age groups (Cai et al., 2022; Ülker & Bülbül, 2018). Ding et al.'s (2017) statements that there are very few studies on digital game-based learning at higher education level also support this view. However, digital games appeal to all ages and are especially interesting for children and young people (Gunter & Daly, 2012; Talan & Kalınkara, 2020; Toh & Lim, 2021). In addition, considering that games have a positive contribution at all grade levels at the secondary school level (Starkey, 2013; Toh & Lim, 2021), the lack of games at the 7th and 8th grade level can be described as a deficiency. Hence, it is advisable to consider the inclusion of interactive digital games within the EIN targeted specifically for 7th and 8th-grade students. It is noteworthy that the learning domain of "data processing and probability" within the secondary school mathematics curriculum comprises a notably reduced number of learning outcomes in comparison to the domains of geometry and algebra, as indicated by the Ministry of National Education (MoNE, 2018). However, despite this, as stated in the results of the study, there are only one game in the same number in the learning areas of data processing, geometry and algebra. Therefore, it is evident that the games in EIN do not align proportionally with the distribution of learning outcomes in the curriculum. In this context, it is suggested that the content of the games in EIN should be designed by considering the number of learning outcomes in the learning areas of the secondary school mathematics curriculum.

In the study, it was determined that the games for geometry, measurement and numbers and operations learning domains in EIN were related to NCTM content standards at a medium level, while the games for data analysis and algebra learning domains were related to NCTM content standards at a low levelIn other words, none of the games in EIN exhibit a high level of alignment with NCTM content standards.One of the reasons for this result may be the differences between the content for learning domains in the secondary school mathematics curriculum in Turkey (MoNE, 2018) and NCTM content standards. While not within the purview of this current study, it is worth acknowledging that the mathematics games hosted within the EIN predominantly concentrate on singular learning outcomes, emphasizing foundational skills at a rudimentary level.It was determined that the games for data analysis and measurement learning domains in EIN were related to problem solving process standards at medium level, while the others were related to problem solving process standards at low level. In other words, none of the games in EIN are highly related to problem solving process standards. Moreover, it is understood that the games in the learning areas of numbers and operations, algebra, and geometry lack problem solving standards. While this result aligns with the findings of Arabacı (2021), in contrast, the study conducted by Joung and Byun (2020) identified problem-solving as the most prevalent standard in games. This finding can be construed as suggestive evidence that the games available within the EIN may be deficient in terms of their emphasis on problem-solving abilities when juxtaposed with other digital games within the international landscape. Considering that problem solving is at the centre of

mathematics teaching (Baki, 2008; MoNE, 2018; NCTM, 2000), it is thought-provoking to obtain such a result. Therefore, it would be appropriate to construct the games by considering the problem solving process standard.

All of the games in EIN are associated with Reasoning and Proofs and communication process standards at a low level. The reason why the games are associated with the Reasoning and proof process standard at a low level may be due to the fact that the study focuses on games at the secondary school level. As a matter of fact, Zeybek et al. (2018) emphasised that words related to proof such as "proof, prove, inference, counter-example, refute" were never encountered in the textbooks, and only 177 of the 2831 mathematical activities they examined had the characteristics of reasoning and proof. Therefore, it is seen that proving is still not considered as a separate skill in secondary school curricula in our country (Öztürk & Demirel, 2021). Conversely, in accordance with the assertions made by Cooper et al. (2011), there exists a conventional paradigm positing the inclusion of proof-related content within the purview of high school and tertiary education, often reserving it exclusively for advanced mathematics contexts. Therefore, the fact that the experts who prepared the games have such a traditional perspective may also explain the result obtained. It is thought that the result that the games are related to the Communication standard at a low level is due to the fact that the games in EIN are individual games. As a matter of fact, Joung and Byun (2021) did not evaluate the communication standard in their research with the assumption that digital games are played individually. In this study, since the feedbacks in the games are also assumed to be communication, the communication standard was taken into consideration. Therefore, the result obtained can be interpreted as that the feedbacks in the games in EIN are insufficient. In contrast to this result, Arabacı (2021) stated that pre-service elementary mathematics teachers identified the communication standard the most in the games they designed. This difference is thought to be related to the type of game designed by the pre-service teachers in the study. As a matter of fact, all of the games designed in the related research are in the non-contact game type and these games are mostly designed as group games. As the researcher stated, it is an expected result that communication skills come to the fore in games played in groups (Arabacı, 2021). Within this context, it is conceivable to propose that games featured on the EIN platform should be meticulously crafted to accommodate multiplayer engagement, thereby facilitating concurrent participation by multiple users. Additionally, individual game designs should be structured to furnish ample feedback mechanisms to enhance the user's learning experience.

While the games for data analysis, algebra and measurement learning domains are moderately related to the connections process standard, geometry and numbers and operations learning domains are related at a low level. Again, it was observed that none of the games in EIN were highly related to the connection process standard. However, it is emphasised that connection is extremely important in mathematics teaching (MoNE, 2018; NCTM, 2000; Pambudi et al., 2020) and students' problem solving skills are affected by mathematical connection (Pambudi et al., 2020; Son et al., 2020); it is also known that there is a positive relationship between mathematical connection and productive thinking (Jawad, 2022) and mathematical reasoning (Hanifah & Karyati, 2019). Therefore, it can be suggested that revisions should be made to design games that are highly related to the connection standard. According to the results of the study, only the game representations for algebra learning domain is moderately related to the process standard. This may be due to the fact that algebra learning domain is highly related to representations by nature (Kaput, 1989). The games for other learning domains were found to be related to the

representations standard at a low level. In other words, most of the learning domains cannot fulfil the representations standard. Vergnaud (1987) stated that representations are a fundamental element for mathematics teaching and learning and Kaput (1987) stated that representations are the heart of the content of mathematics and are at the centre of mathematical activities. Indeed, the important role of representation in mathematics is strongly supported by NCTM (2000).

It was determined that the games belonging to the geometry learning domain in EIN were associated with all NCTM process standards at a low level. Also, no significant difference emerged in terms of process standards in the games belonging to the geometry learning domain. In other words, no process standard was emphasized in the geometry learning domain. Similarly, although the games belonging to the numbers and operations learning domain were associated with all process standards at a low level, it was found that the problem solving process standard differed significantly from reasoning and proof in the games in this learning domain. Additionally, connections standard is also significantly differentiated from reasoning and proof and communication. Therefore, although the games belonging to the numbers and operations learning domain do not meet the process standards, it is understood that these games are more related to the problem solving standard than reasoning and proof, and more related to the connections standard than reasoning and proof and communication. It was found that the games for the data analysis learning domain were more related to problem solving and connections standards; moreover, the relationship with these standards differed significantly from communication and reasoning and proof. Likewise, it is worth noting that the games within the measurement learning domain exhibited a moderate degree of correlation with problem-solving and connections. Within this specific learning domain, the scores associated with the problem-solving process standard displayed notable disparities when compared to the standards of reasoning and proof, as well as communication, signifying a significant differentiation among them. It was found that the games belonging to the algebra learning domain were moderately related to connections and representations process standards, and these standards differed significantly from reasoning and proof. Moreover, the scores belonging to the connections standard are significantly higher than communication.

In conclusion, according to the results of the study, the games in EIN do not meet any of the process standards at a high level. Moreover, there is no significant difference in terms of process standards in geometry learning domain. However, a significant difference was found in terms of process standards in the games belonging to data, algebra and numbers learning domains. In other words, some process standards are found more in the games belonging to data, algebra and numbers learning domains than others. Hence, it is deemed imperative to take into account the mathematical process standards both during the revision of existing games across all learning domains and in the developmental phase of new digital games. Considering that games enhance mathematics achievement in mathematics education, it is advisable to include more game-based content in digital platforms like EIN and in MoNE textbooks (Tarım, 2023).

Ethics

We declare that the research was conducted in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Author Contributions

All authors contributed equally to the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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References

Acquah, E. O., & Katz, H. T. (2020). Digital game-based L2 learning outcomes for primary through high-school students: A systematic literature review. *Computers & Education, 143*, 103667. https://doi.org/10.1016/j.compedu.2019.103667

Akkaş Dede, R. (2021). *Teknoloji destekli eğitsel oyunların ilköğretim matematik öğretiminde kullanılmasına yönelik yazılan lisansüstü araştırmaların eğilimleri: 2005-2020 yılları arası Türkiye örneği* [Trends of graduate research on the use of technology aid educational games in primary education mathematics teaching: Turkey case between 2005-2020] [Unpublished master's thesis]. Kocaeli University.

Alabdulaziz, M. S., & Higgins, S. (2021). The compatibility of developed mathematics textbook content in Saudi Arabia with NCTM Standards: A critical review. *International Journal of Instruction, 14*(2), 461-482. https://doi.org/10.29333/iji.2021.14226a

Alaswad, Z., & Nadolny, L. (2015). Designing for game-based learning: The effective integration of technology to support learning. *Journal of Educational Technology Systems, 43*(4), 389-402. https://doi.org/10.1177/0047239515588164

Alexiou, A., & Schippers, M. C. (2018). Digital game elements, user experience and learning: A conceptual framework. *Education and Information Technologies, 23*, 2545-2567. https://doi.org/10.1007/s10639-018-9730-6

Altman, D. G. (1999). *Practical statistics for medical research.* Chapman & Hall CRC Press.

Anastasiadis, T., Lampropoulos, G., & Siakas, K. (2018). Digital game-based learning and serious games in education. *International Journal of Advances in Scientific Research and Engineering, 4*(12), 139-144. http://doi.org/10.31695/IJASRE.2018.33016

Arabacı, D. (2021). Examination of the games developed by pre-service elemantary mathematics teachers based on the NCTM content and process standards. *Technology, Innovation and Special Education Research Journal, 1*(1), 43-61.

Baki, A. (2008). *Kuramdan uygulamaya matematik eğitimi*. Harf Yayıncılık.

Bakker, M., den Heuvel-Panhuizen, V., Robitzsch, A., Sun, X., Kaur, B., & Novotná, J. (2015). *Learning multiplicative reasoning by playing computer games*. ICMI Study 23.

Barros, C., Carvalho, A. A., & Salgueiro, A. (2020). The effect of these rious game Tempoly on learning arithmetic polynomial operations. *Education and Information Technologies, 25*, 1497-1509. https://doi.org/10.1007/s10639-019-09990-4

Bofferding, L., & Hoffman, A. (2019). Children's integer understanding and the effects of linear board games: A look at two measures. *The Journal of Mathematical Behavior, 56*, 100721. https://doi.org/10.1016/j.jmathb.2019.100721

Cai, Z., Mao, P., Wang, D., He, J., Chen, X., & Fan, X. (2022). Effects of scaffolding in digital game-based learning on student's achievement: A three-level meta-analysis. *Educational Psychology Review*, *34*(2), 537-574. https://doi.org/10.1007/s10648-021-09655-0

Chizary, F., & Farhangi, A. (2017). Efficiency of educational games on mathematics learning of students at second grade of primary school. *Journal of History Culture and Art Research, 6*(1), 232-240. https://doi.org/10.7596/taksad.v6i1.738

Connolly, T.M., Boyle, E.A., Macarthur, E., Hainey, T., ve Boyle, J. M., (2012). A systematic literature review of empirical evidence on computer games and serious games. *Computers ve Education, 59* (2), 661-686. https://doi.org/10.1016/j.compedu.2012.03.004

Cooper, J. L., Walkington, C. A., Williams, C. C., Akinsiku, O. A., Kalish, C. W., Ellis, A. B., & Knuth, E. J. (2011, July). Adolescent reasoning in mathematics: exploring middle school students' strategic approaches ın empirical justifications. Paper presented at the 33rd Annual Conference of the Cognitive Science Society. Boston, MA.

Cramer, J. (2019). Games as a means of motivating more students to participate in argumentation. In *Eleventh Congress of the European Society for Research in Mathematics Education* (No. 10). Freudenthal Group; Freudenthal Institute; ERME.

Dai, C. P., Ke, F., & Pan, Y. (2022). Narrative-supported math problem solving in digital game-based learning. *Educational technology research and development*, *70*(4), 1261-1281. https://doi.org/10.1007/s11423-022-10129-5

Dayo, N., Asad, M. M., & Alvi, U (2021). Effects of digital game-based learning and traditional teaching approaches on students' mathematics problem-solving attitude. In *Innovative education Technologies for 21st century teaching and learning* (pp. 101-112). CRC Press.

De Freitas, S. I. (2006). Using games and simulations for supporting learning. *Learning, media and technology*, *31*(4), 343-358. https://doi.org/10.1080/17439880601021967

Deal, L. J., & Wismer, M. G. (2010). NCTM Principles and Standards for mathematically talented students. *Gifted Child Today*, *33*(3), 55-65.

Deng, L., Wu, S., Chen, Y., & Peng, Z. (2020). Digital game-based learning in a Shanghai primary-school mathematics class: A case study. *Journal of Computer Assisted Learning*, *36*(5), 709-717. https://doi.org/10.1111/jcal.12438

Devlin, K. (2011). *Mathematics education for a new era: Video games as a medium for learning*. CRC Press.

Ding, D., Guan, C., & Yu, Y. (2017). Game-based learning in tertiary education: A new learning experience for the generation Z. *International Journal of Information and Education Technology*, *7*(2), 148. https://doi.org/10.18178/ijiet.2017.7.2.857

Ding, D., Guan, C., & Yu, Y. (2017). Game-based learning in tertiary education: A new learning experience for the generation Z. *International Journal of Information and Education Technology*, *7*(2), 148-152. https://doi.org/10.18178/ijiet.2017.7.2.857

Drijvers, P., Doorman, M., Boon, P., Reed, H., & Gravemeijer, K. (2010). The teacher and the tool: Instrumental orchestrations in the technology-rich mathematics classroom. *Educational Studies in mathematics*, *75*, 213-234. https://doi.org/10.1007/s10649-010-9254-5

Dweck, C. S. (2015). Ca Carol Dweck revisits the growth mindset. *Education Week, 35*(5), 20-24.

Ebner, M., & Holzinger, A. (2007). Successful implementation of user-centered game based learning in higher education: An example from civil engineering. *Computers & education*, *49*(3), 873-890. https://doi.org/10.1016/j.compedu.2005.11.026

Gareau, S., & Guo, R. (2009). " All Work and No Play" reconsidered: The use of games to promote motivation and engagement in instruction. *International Journal for the Scholarship of Teaching and Learning*, *3*(1), Article 12. https://doi.org/10.20429/ijsotl.2009.030112

Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave Macmillan.

Gee, J. P. (2007). Good video games and good learning. *Phi Kappa Phi Forum*, *85*(2), 33-37.

Gözüm, A. İ. C., & Kandır, A. (2021). Digital games pre-schoolers play: Parental mediation and examination of educational content. *Education and Information Technologies*, *26*(3), 3293-3326. https://doi.org/10.1007/s10639-020-10382-2

Gros, B. (2007, March). The design of learning environments using videogames in formal education. In *2007 First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL'07)* (pp. 19-24). IEEE.

Gunter, W. D., & Daly, K. (2012). Causal or spurious: Using propensity score matching to detangle the relationship between violent video games and violent behavior. *Computers in Human Behavior*, *28*(4), 1348-1355. https://doi.org/10.1016/j.chb.2012.02.020

Günbaş, N. & Öztürk A., N. (2022). Eğitim bilişim ağı (EBA) içeriklerinde yer alan dijital matematik oyunlarının Bloom taksonomisine göre incelenmesi [Evaluation of digital mathematics games in Education Information Network (EBA) based on Bloom's taxonomy]. *e- Kafkas Eğitim Araştırmaları Dergisi,* 9, 253-278. https://doi.org/10.30900/kafkasegt.1009879

Hamari, J., Shernoff, D. J., Rowe, E., Coller, B., Asbell-Clarke, J., & Edwards, T. (2016). Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. *Computers in human behavior*, *54*, 170-179. http://dx.doi.org/10.1016/j.chb.2015.07.045

Hanifah, L. H., & Karyati, K. (2019). The relation between mathematical connection ability and mathematical reasoning ability of senior high school student. In A. Nugroho & D. Hasan (Eds), *Proceeding 1st International*

Seminar STEMEIF (Science, Technology, Engineering and Mathematics Learning International Forum) "Strengtheing the STEM Education and Digital Skills" (pp. 310-315). UM Purwokerto Press. Retrieved from https://digitallibrary.ump.ac.id/343/

Haskanlı, B. (2021). *8. Sınıf doğrusal denklemlerin öğretiminde EBA ile öğretimin etkisi [The effect of teaching with EBA on the teaching linear equations in 8th grade]* [Unpublid master's thesis]. Kastamonu University.

Herger, M. (2014). *Enterprise gamification: Engaging people by letting them have fun.* Los Altos, CA: CreateSpace Independent Publishing Platform.

Hwang, G. J., Chiu, L. Y., & Chen, C. H. (2015). A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses. *Computers & Education*, *81*, 13-25. https://doi.org/10.1016/j.compedu.2014.09.006

Ibrahim, R., & Jaafar, A. (2009). Educational games (EG) design framework: Combination of game design, pedagogy and content modeling. *Proceedings of the 2009 international conference on electrical engineering and informatics*. IEEE, Malaysia. https://doi.org/10.1109/ICEEI.2009.5254771

ISSA. (2007). Digital games may offer health benefits, Experts suggest. Retrieved from http://www.issaonline.com/ pressroom/ downloads/exertainment.pdf

Jacobs, J. E., Hiebert, J., Givvin, K. B., Hollingsworth, H., Garnier, H., & Wearne, D. (2006). Does eighth-grade mathematics teaching in the United States align with the NCTM Standards? Results from the TIMSS 1995 and 1999 video studies. *Journal for research in mathematics education*, *37*(1), 5-32.

Jarrah, A. M., Almassri, H., Johnson, J. D., & Wardat, Y. (2022). Assessing the impact of digital games-based learning on students' performance in learning fractions using (ABACUS) software application. *EURASIA Journal of Mathematics, Science and Technology Education*, *18*(10), em2159. https://doi.org/10.29333/ejmste/12421

Jawad, L. F. (2022). Mathematical connection skills and their relationship with productive thinking among secondary school students. *Periodicals of Engineering and Natural Sciences*, *10*(1), 421-430. http://dx.doi.org/10.21533/pen.v10i1.2667

Jenkins, H., Clinton, K., Purushotma, R., Robinson, A. J., & Weigel, M. (2006). *Confronting the challenges of participatory culture: Media education for the 21st century*, *66*, Washington, DC: The John D. And Catherine Mac Arthur Foundation.

Jensen, E. O., & Skott, C. K. (2022). How can the use of digital games in mathematics education promote students' mathematical reasoning? A qualitative systematic review. *Digital Experiences in Mathematics Education*, *8*(2), 183-212. https://doi.org/10.1007/s40751-022-00100-7

Joung, E., & Byun, J. (2021). Content analysis of digital mathematics games based on the NCTM Content and Process Standards: An exploratory study. *School Science and Mathematics*, *121*(3), 127-142. http://dx.doi.org/10.1111/ssm.12452

İskender, H. (2016). Eğitim bilişim ağı'nda bulunan 7. Sınıf türkçe dersi videolarının ilköğretim türkçe dersi (6, 7, 8. Sınıflar) öğretim programıyla uyumu [Conformity of 7th grade Turkish course videos on the educational informatics network with the Turkish Curriculum (6th, 7th, and 8th grades)]. *Adiyaman University Journal of Social Sciences, 1*(3), 1042–1068.

Kaput, J. J. (1987). Representation systems and mathematics. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 19-26). New Jersey: Lawrence ErlbaumAssociates.

Kaput, J. J. (1989). Linking representations in the symbol systems of algebra. In S. Wagner ve C. Kieran (Eds). *Research issues in the learning and teaching of algebra* (pp. 167-194). Lawrence EribaumAssociates. https://doi.org/10.4324/9781315044378

Kärki, T., McMullen, J., & Lehtinen, E. (2022). Improving rational number knowledge using the NanoRoboMath digital game. *Educational Studies in Mathematics, 110*, 101-123. https://doi.org/10.1007/s10649-021-10120-6

Ke, F. (2014). An implementation of design-based learning through creating educational computer games: A case study on mathematics learning during design and computing. *Computers & Education, 73*, 26-39. https://doi.org/10.1016/j.compedu.2013.12.010

Kepceoğlu, İ., & Ercan, P. (2019). Ortaokul matematik dersi EBA içeriğinde yer alan uzamsal becerilerle ilgili etkinlikler hakkındaki öğretmen görüşleri [Teachers' Views about Middle School Mathematics Content in Educational Information Network in Terms of Spatial Ability and Its Components]. *Inonu University Journal of the Faculty of Education, 20*(1), 191-207. https://doi.org/10.17679/inuefd.422775

Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education, 52*(4), 800-810. https://doi.org/10.1016/j.compedu.2008.12.004

Kirriemuir, J., & McFarlane, A. (2004). Literature review in games and learning. Futurelab Series: Report 8.

Koç Deniz, H. (2019). *Matematik dersinde oyun ve etkinlik destekli ters yüz sınıf modelinin öğrenci başarısına, problem çözme ve problem çözmeye yönelik yansıtıcı düşünme becerilerine etkisi* [The effect of game and activity supported flipped classroom model on students` achievement in problem solving skill and reflective thinking skill based on problem solving in mathematics course] [Unpublished doctoral dissertation]. Fırat University.

Kolovou, A., van den Heuvel-Panhuizen, M., & Köller, O. (2013). An intervention including an online game to improve grade 6 students' performance in early algebra. *Journal for Research in Mathematics Education, 44*(3), 510-549.

Landers, R. N., & Landers, A. K. (2014). An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance. *Simulation & Gaming, 45*(6), 769-785. https://doi.org/10.1177/1046878114563662

Lee, J. Y., Pyon, C. U., & Woo, J. (2023). Digital twin for math education: A study on the utilization of games and gamification for university mathematics education. *Electronics, 12*(15), 3207. https://doi.org/10.3390/electronics12153207

Liu, T. Y., & Chu, Y. L. (2010). Using ubiquitous games in an English listening and speaking course: Impact on learning outcomes and motivation. *Computers & Education*, *55*(2), 630-643. https://doi.org/10.1016/j.compedu.2010.02.023

Luo, T., Hickman, C., & Muljana, P. (2022). Examining the impact of online math games on student performance and attitudes. *Journal of Educational Multimedia and Hypermedia*, *31*(1), 17-41.

Malone, T. W. (1981). Toward a theory of intrinsically motivating instruction. *Cognitive science*, *5*(4), 333-369.

MEB. (2018). Ortaokul matematik dersi (5, 6, 7 ve 8. sınıflar) öğretim programı. Ankara: Milli Eğitim Basımevi. Retrieved at 14 June 2022 from http://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=329

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

Midgett, C. W., & Eddins, S. K. (2001). NCTM's principles and standards for school mathematics: Implications for administrators. *Nassp Bulletin*, *85*(623), 35-42.

Ministry of National Education [MoNE] (2018). *Matematik Dersi Öğretim Programı (İlkokul ve Ortaokul 1, 2, 3, 4, 5, 6, 7 ve 8. Sınıflar) [Mathematics Curriculum (Primary and Secondary Grades 1, 2, 3, 4, 5, 6, 7 and 8th)]*. Ministry of National Education Publications.

Moyer-Packenham, P.,Litster, K., Roxburgh, A.L., Kozlowski, J.S. & Ashby, M.J. (2019). Relationships between Mathematical Language, Representation Connections, and Learning Outcomes in Digital Games. In K. Graziano (Ed.), *Proceedings of Society for Information Technology & Teacher Education International Conference* (pp. 2201-2209). Association for the Advancement of Computing in Education (AACE). Retrieved from https://www.learntechlib.org/primary/p/207953/

National Council of Teachers of Mathematics [NCTM] (2000). *Principles and standards for school mathematics.* Author.

Olson, C. K., Kutner, L. A., Warner, D. E., Almerigi, J. B., Baer, L., Nicholi II, A. M., & Beresin, E. V. (2007). Factors correlated with violent video game use by adolescent boys and girls. *Journal of Adolescent Health*, *41*(1), 77-83. https://doi.org/10.1016/j.jadohealth.2007.01.001

Özata, M., & Coşkuntuncel, O. (2019). Ortaokul matematik öğretmenlerinin matematik öğretiminde eğitsel matematik oyunlarının kullanımına ilişkin görüşleri [Opinions of secondary school mathematics teachers on theuse of educational math games in mathematics teaching]. *Mersin University Journal of the Faculty of Education*, *15*(3), 662-683. https://doi.org/10.17860/mersinefd.619983

Öztürk, T. ve Demirel, D. (2022). The analysis of the studies on proof in Turkey: A systematic review. *Pamukkale University Journal of Education, 54*, 32-68. https://doi.org/10.9779/pauefd.782832

Pambudi, D. S., Budayasa, I. K., & Lukito, A. (2020). The role of mathematical connections in mathematical problem solving. *Jurnal Pendidikan Matematika, 14*(2), 129-144. https://doi.org/10.22342/jpm.14.2.10985.129-144

Peterson, M. (2010). Massively multiplayer online role-playing games as arenas for second language learning. *Computer assisted language learning*, *23*(5), 429-439. https://doi.org/10.1080/09588221.2010.520673

Pilten, P., Pilten, G., Divrik, R., & Divrik, F. (2017). Evaluation of mathematical game design skills of pre-service classroom teachers. *International Electronic Journal of Elementary Education, 10*(2), 255-264. http://dx.doi.org/10.26822/iejee.2017236120

Poçan, S., & Yaşaroğlu, C. (2017). Dikişsiz öğrenme (Seamless Learnıng) ilkeleri bağlamında EBA'nın matematik ders içeriğinin incelenmesi [Examination of the mathematics contents of EBA in the context of seamless learning principles]. *Journal Of International Social Research, 10*(51), 795-806. http://dx.doi.org/10.17719/jisr.2017.1816

Prensky, M. (2001). Digital natives, digital immigrants. *On the Horizon, 9*(5), 1-6.

Prensky, M. (2006). *Don't bother me, mom, I'm learning!: How computer and video games are preparing your kids for 21st century success and how you can help!*. St. Paul, MN: Paragon house.

Ramani, G. B., & Siegler, R. S. (2008). Promoting broad and stable improvements in low-income children's numerical knowledge through playing number board games. *Child development*, *79*(2), 375-394. https://doi.org/10.1111/j.1467-8624.2007.01131.x

Ray, B., & Coulter, G. A. (2010). Perceptions of the value of digital mini-games: Implications for middle school classrooms. *Journal of Computing in Teacher Education*, *26*(3), 92-100. https://doi.org/10.1080/10402454.2010.10784640

Ribeiro, M. D. C. (2019). Analog and digital games as a pedagogical tool in the teacher training context. *Research in Social Sciences and Technology*, *4*(2), 163-173.

Riopel, M., Nenciovici, L., Potvin, P., Chastenay, P., Charland, P., Sarrasin, J. B., & Masson, S. (2019). Impact of serious games on science learning achievement compared with more conventional instruction: An overview and a meta-analysis. *Studies in Science Education*, *55*(2), 169-214. https://doi.org/10.1080/03057267.2019.1722420

Samur, Y. (2016). *Dijital oyun tasarımı*. Pusula.

Son, AL, Sudirman, S., & Widodo, SA (2020). Association of mathematical connections and problem-solving ability: Cross-sectional in West Timor. *AKSIOMA: Journal of Mathematics Education Study Program, 9* (2), 326–337. https://doi.org/10.24127/ajpm.v9i2.2742

Song, M., & Zhang, S. (2008). EFM: A model for educational game design. *Proceedings of the International Conference on Technologies for e-Learning and Digital Entertainment*. Springer.

Spires, H. A. (2015). Digital game-based learning: What's literacy got to do with it?. *Journal of Adolescent & Adult Literacy*, *59*(2), 125-130.

Starkey, P. L. (2013). *The effects of digital games on middle school students' mathematical achievement* [Doctoral dissertation]. Lehigh University.

Stoll, J.A. (2015). *An exploratory study of preschool teachers' perceive knowledge behaviors and attitudes/beliefs regarding the National Council of Teacher of Mathematics (NCTM) process standards* [Doctoral dissertation]. Kent State University.

Sun, C. T., Chou, K. T., & Yu, H. C. (2022). Relationship between digital game experience and problem-solving performance according to a PISA framework. *Computers & Education, 186*, 104534. https://doi.org/10.1016/j.compedu.2022.104534

Sykes, J. M. (2018). Digital games and language teaching and learning. *Foreign Language Annals*, *51*(1), 219-224. https://doi.org/10.1111/flan.12325

Tabachnick, B.G. & Fidell, L.S. (2012). *Using multivariate statistics.* Person Education.

Talan, T., & Kalınkara, Y. (2020). Investigation of secondary school students' tendencies to playing digital games and computer game addiction levels: The case of Malatya province. *Journal of Instructional Technologies and Teacher Education*, *9*(1), 1-13.

Tangkui, R., & Keong, T. C. (2020). Enhancing pupils' higher order thinking skills through the lens of activity theory: Is digital game-based learning effective?. *International Journal of Advanced Research in Education and Society*, *2*(4), 1-20.

Tarım, E. N. (2023). *Matematik eğitiminde oyun: Bir meta-analiz çalışması [Game in mathematics education: A meta-analysis study]* [Unpublished master's thesis]. İstanbul Medeniyet University.

Toh, W., & Lim, F. V. (2021). Using video games for learning: Developing a metalanguage for digital play. *Games and Culture*, *16*(5), 583-610. https://doi.org/10.1177%2F1555412020921339

Toumasis, C. (1997). The NCTM standards and the philosophy of mathematics. *Studies in Philosophy and Education*, *16*(3), 317-330.

Tuluk, G., & Akyüz, H. İ. (2019). Öğretmen ve öğretmen adaylarının eba içerik incelemesi: 5. sınıf sayılar alt öğrenme alanı doğal sayılar ünitesi [Investigation of eba contents by teacher and teacher candidates: 5th grade natural numbers unit]. *Usak University Journal Of Social Sciences*, *12*(2), 32-47.

Uğurel, İ., & Moralı, S. (2010). Ortaöğretim matematik derslerinde oyunlarin kullanilabilirliği [Usability of games in high school mathematics lessons]. *Journal of National Education, 40*(185), 328-352.

Umay, A., Duatepe-Paksu, A., & Akkuş, O. (2006). İlköğretim 1.-5. sınıf matematik yeni öğretim programının NCTM prensip ve standartlarına göre incelenmesi [An investigation of 1.-5. Grades Mathematics Curriculum by considering NCTM Principles and Standards]. *Hacettepe University Journal of Education, 31*, 198-211.

Umbara, U., Susilana, R., & Puadi, E. F. W. (2021). Algebra dominoes game: Re-designing mathematics learning during the COVID-19 pandemic. *International Journal of Instruction, 14*(4), 483-502. https://doi.org/10.29333/iji.2021.14429a

Üce, Ş. (2019). *İlkokullarda görev yapan öğretmenlerin kişiler arası öz-yeterlikleri ile araç gereç kullanımına yönelik tutumlarının incelenmesi* [*Investigation of teachers' self-efficacy and attitudes towards the use of tools in elementary school] [Unpublised master's thesis]*. Marmara University.

Ülker, Ü., & Bülbül, H. İ. (2018). Dijital oyunların eğitim seviyelerine göre kullanılma durumları [The usage status of digital games according to educational levels]. *Tübav Bilim Dergisi, 11*(2) , 1-10.

Van Eck, R. (2015). Digital game-based learning: Still restless, after all these years. *EDUCAUSE Review, 50*(6), 13-28.

Vergnaud, G. (1987). Conclusion. In C. Janvier, (Ed.). *Problems of representations in the teaching and learning of mathematics* (pp. 227-232). New Jersey: Lawrence Erlbaum, Hillsdale.

Vogel, J. J., Vogel, D. S., Cannon-Bowers, J., Bowers, C. A., Muse, K., & Wright, M. (2006). Computer gaming and interactive simulations for learning: A meta-analysis. *Journal of Educational Computing Research, 34*(3), 229-243.

Wang, L. C., & Chen, M. P. (2010). The effects of game strategy and preference-matching on flow experience and programming performance in game-based learning. *Innovations in Education and Teaching International, 47*(1), 39-52. https://doi.org/10.1080/14703290903525838

White, K., & McCoy, L. P. (2019). Effects of game-based learning on attitude and achievement in elementary mathematics. *Networks: An Online Journal for Teacher Research, 21*(1), 1-17. https://doi.org/10.4148/2470-6353.1259

Yin, R. K. (2016). *Qualitative research from start to finish*. The Guilford Press.

Yüksel, H. (2019). *Türkçe dersinde kullanılan eğitsel dijital oyunların ders başarısı ve motivasyona etkisi [The effect of educational digital games used in Turkish course on course success and motivation]* [Unpublished master's thesis]. Zonguldak Bülent Ecevit University.

Yong, S. T., Gates, P., & Harrison, I. (2016). Digital games and learning mathematics: Student, teacher and parent perspectives. *International Journal of Serious Games, 3*(4), 55-68. http://dx.doi.org/10.17083/ijsg.v3i4.112

Zeybek, Z., Üstün, A., & Birol, A. (2018). The place of mathematical proofs in the middle grade mathematics textbooks. *İlkogretim Online, 17*(3), 1317-1335. https://doi.org/10.17051/ilkonline.2018.466349