Multimodal Technologies and Interaction

Article

Effects of Kahoot! on K-12 Students' Mathematics Achievement and Multi-Screen Addiction

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Abstract: Digital platforms are increasingly prevalent among young students in K-12 education, offering significant opportunities but also raising concerns about their effects on self-assessment and academic performance. This study investigates the effectiveness of Kahoot! compared to traditional instructional methods in enhancing mathematics achievement and its impact on multiple screen addiction (MSA) among Greek students aged 9 to 12 during a STEM summer camp. A quasi-experimental design was employed with a purposefully selected sample of one hundred and ten (n = 110) students, who were non-randomly divided into two groups: (a) an experimental group of fifty-five students (n = 55) who engaged with Kahoot! (using dynamic visual aids and interactive content) and (b) a control group of fifty-five students (n = 55) who received traditional instruction (using digital textbooks and PowerPoint slides with multimedia content) on laptops and tablets. The findings revealed a statistically significant difference in MSA scores, with the experimental group exhibiting lower MSA scores compared to their counterparts, indicating a positive impact on reducing screen addiction levels. While Kahoot! led to lower MSA levels, it significantly improved overall mathematical achievement, with a substantial effect size, suggesting a strong positive impact on learning outcomes. The current study highlights the importance of aligning educational tools with the intended outcomes and recommends further research to explore the broader impact of gamified learning on student engagement, screen addiction, and learning outcomes.

Keywords: student performance; Kahoot!; primary education; mathematics; multiple screen addiction

Citation: Pellas, N. Effects of Kahoot! on K-12 Students' Mathematics Achievement and Multi-Screen Addiction. *Multimodal Technol. Interact.* **2024**, *8*, 81. https://doi.org/10.3390/mti8090081

Academic Editors: Jerry Alan Fails and Julius Nganji

Received: 22 August 2024
Revised: 13 September 2024
Accepted: 14 September 2024
Published: 16 September 2024

1. Introduction

Instructional design is essential for creating effective learning experiences across various formats, including online and face-to-face courses, workshops, and training programs, among K-12 students [1]. It facilitates learning by ensuring that students gain knowledge, improve skills, or change behavior while remaining engaged and motivated [2]. This involves setting clear instructional objectives, delivering accurate and relevant content through different media (text, images, videos, etc.), and incorporating activities and assessments to apply and evaluate learning [3]. Activities like quizzes, discussions, case studies, or other exercises help learners apply their knowledge and skills. Finally, assessments evaluate how well learners have achieved their learning [4,5].

For subjects like mathematics, well-designed content moves beyond passive lectures to include interactive activities and problem solving, catering to varied learning styles and making abstract concepts more tangible [6–8]. This approach helps address the limitations of traditional methods and the challenges posed by constant digital stimulation [9]. By considering students' age, knowledge, and learning styles, the content fosters relevance and appropriate challenge. Some researchers [7,8] advocated replacing passive lectures, which inherently favor teacher-centered instruction and rote memorization, with interactive activities, problem solving, and collaboration. This shift transforms math from memorization into a process of exploration and discovery, aligning perfectly with the way students naturally engage with the world around them. While traditional methods like textbooks and chalkboards remain valuable resources, their reliance on passive learning approaches can limit engagement and fail to compete with the constant stimulation readily available on multiple screens [9]. This highlights the need for innovative instructional design that not only delivers content effectively but also fosters active participation and a sense of enjoyment in the learning process [4].

Students today are inseparable from their smartphones, tablets, and laptops, constantly interacting with digital platforms throughout the day. This presents both challenges and opportunities for education. Educators can leverage this constant engagement by incorporating interactive quizzes, simulations, and educational apps alongside traditional materials. These approaches provide to different learning styles, boost engagement, and create an interactive learning environment that competes with, without succumbing to, the allure of other digital distractions [5]. A wide array of technological devices and the increased time spent using them have led to a tendency to addiction to multiple devices, applications, and services. By blending visual and auditory features with text, video, and animated graphics, multimedia tools can enhance understanding and retention of information [10]. Consequently, individuals often use multiple devices simultaneously, exhibiting multi-screen consumption behavior that involves interacting with various types of features and elements projected across different platforms [11].

Multiple screen addiction (MSA) is a significant issue because MSA not only affects students' engagement but also their overall academic performance. It specifically refers to the uncontrollable and compulsive use of various screen devices, resulting in detrimental effects on multiple aspects of an individual's life [12]. This addiction shows not only in excessive screen use but also in the discomfort and negative emotions experienced when access to these devices is limited [13]. Additionally, the concept of screen addiction encompasses a broader range of problematic media behaviors involving multiple screens, extending from excessive consumption to a more severe, pathological level of use, where the behavior significantly disrupts daily life [14]. This unveils challenges, particularly in subjects requiring sustained focus like mathematics, which require sustained attention and problem solving [15]. A promising approach to address these challenges in mathematics education lies in interactive learning platforms like Kahoot! (https://kahoot.com/, accessed on 8 May 2024). It offers a promising approach to enhance student engagement and achievement by allowing them to use a variety of computing devices, such as laptops, tablets, or smartphones [16]. This platform leverages game-based learning and dynamic environments to promote active participation and enjoyment specifically in the learning of mathematical concepts [17]. Kahoot!'s "playable" features and tasks create an engaging and stimulating learning experience for mathematics, potentially fostering a deeper understanding of concepts through a more enjoyable and interactive approach [18,19].

Despite the widespread adoption of technology in mathematics, there is a need to empirically assess the impact of specific digital tools on student MSA and achievement. On the one hand, traditional instructional design methods, often reliant on passive learning approaches like lectures with (digital) slideshows using PowerPoint (ver. 365), can struggle to compete with the stimulation readily available on multiple screens [8,20]. This lack of engagement might inadvertently contribute to MSA as students seek more stimulating distractions on their devices. On the other hand, popular game-based learning platforms like Kahoot! can be used on various mobile devices to promote interactive learning experiences in instructional design content creation for mathematics education. Its potential benefits for engagement and knowledge retention are widely recognized, while concerns exist regarding its contribution to screen time overload and the development of MSA among students [11,21]. Therefore, this study seeks to determine the impact of Kahoot! in comparison to traditional teaching methods, addressing these questions through the following two research questions (RQs):

- *RQ1: Is there any significant difference between the MSA of students who followed Kahoot!-supported instruction and their counterparts who received traditional instruction?*

- *RQ2: Is there any significant difference between the performance of students who followed Kahoot!-supported instruction and their counterparts who received traditional instruction?*

This study aimed to investigate the impact of integrating Kahoot! as an instructional tool on students' achievements and its potential influence on MSA, focusing on mathematics education. The findings will contribute to a deeper understanding of the complex interplay between technology, learning, and student success in the era of pervasive screen use.

2. Background

2.1. Multiple Screen Addiction (MSA)

MSA, characterized by the excessive and simultaneous use of multiple devices, has become a growing concern, especially among younger generations. People with MSA struggle to control their screen usage, experiencing withdrawal symptoms like anxiety, loss of productivity, and feelings of emptiness when unable to access their devices [14]. This excessive and compulsive media consumption can be seen on televisions, laptops, tablets, and smartphones. The visually appealing process of using multimedia content and other non-educational content readily available on multiple screens can significantly distract students from their studies. This distraction can lead to lower achievements. Frequent interruptions caused by checking other screens can also result in incomplete or subpar assignments as students struggle with time management. Multitasking itself can lead to mistakes and lower-quality work due to divided attention and effort put into educational tasks [13]. The constant entry of information and pressure to respond to multiple stimuli from various screens can increase stress and anxiety levels in students. Overuse of screens, even for educational purposes, can lead to burnout, where students feel overwhelmed and disengaged [12].

Multiple screen use can negatively affect cognitive functions crucial for effective learning. Regular switching between devices, such as web-based platforms and smartphones, can reduce the ability to concentrate for extended periods, leading to a decreased attention span. This fragmented attention can result in students missing critical information or instructions presented on educational platforms [11,22]. Other studies [14–16] have also pointed out that divided attention can impair memory retention. When students constantly switch between devices during educational sessions, they may retain less information overall. Furthermore, multiple screen usage often promotes "surface learning"—focusing on quick answers rather than deep, meaningful engagement with the material. There is a growing body of research on MSA with different perspectives. Lin et al. [14] found a positive correlation between media multitasking (using multiple devices simultaneously) and screen addiction. Their study also suggests that screen use mediates the effect of media multitasking on addiction, meaning screen time itself plays a significant role. Saritepeci [12] advocated that MSA is a behavioral addiction, such as smartphone addiction or internet addiction. A key indicator of such addictions is the distress caused by being unable to access the desired object or activity (e.g., feeling uncomfortable without a smartphone). MSA, where individuals simultaneously engage with multiple digital devices, can lead to fragmented attention and reduced performance. This behavior often results in diminished concentration and lower achievement, counteracting the positive effects of educational technologies. Previous research [2,23] has also demonstrated the potential of educational platforms and applications to enhance student engagement and classroom participation. These tools provide immediate feedback and encourage active involvement, fostering enthusiasm and stimulating student discussions. Given the complex nature of MSA factors and their potential interconnections, a comprehensive investigation is essential to understand more about their impact on students' performance in regular learning subjects.

While research has extensively documented the negative consequences of excessive screen time on student learning and well-being, there is still a significant research "gap" in understanding how educational technologies can be leveraged to mitigate this issue. The potential of gamified learning platforms, such as Kahoot!, to address the effects of MSA remains largely unexplored. This study aims to investigate the relationship between

Kahoot! usage and excessive screen time levels among students using different devices. Consequently, research should also consider the broader implications of digital platforms on student engagement and investigate whether there is a link with students' learning performance to inform educators about the design and development of more effective instructional content.

2.2. The Kahoot! Platform

Kahoot! (https://kahoot.com/, accessed on 8 May 2024) headquartered in Oslo, Norway. It is a Norwegian online game-based learning platform that offers learning games, known as 'kahoots', which are us-er-generated multiple-choice quizzes accessible via a web browser or the Kahoot! application, available on Google Play and Apple Store. Kahoot! is an interactive online learning platform that blends education with fun. Accessible on both mobile devices and computers, Kahoot! uses interactive quizzes and games to make learning engaging and enjoyable.

Students can access a wide range of educational content anytime, anywhere. The interactive and competitive nature of the platform, with points, leaderboards, and timers, makes learning fun and motivates students to participate actively [10]. Kahoot!'s user-friendly interface and simple setup make it easy for both teachers and students to use. This seamless integration enhances the learning experience. Incorporating Kahoot! within the assessment strategy offers the additional benefit of immediate feedback. This real-time feedback allows students to grasp and learn from their errors promptly, fostering a more effective learning experience and enhancing comprehension and retention of the material [24]. Furthermore, the regular use of Kahoot! for quizzes and reviews reinforces learning and promotes better memory retention through repeated exposure to the information.

While Kahoot offers several benefits, there still exist potential drawbacks to ensure its effective use inside the classroom. Students using the platform on mobile devices alongside other applications might get distracted by notifications, games or social media in multitasking settings, hindering their focus on educational content. While competition can be motivating, it can also lead to anxiety or stress for some students. This can have a negative impact on their learning experience, especially for those who struggle with test anxiety. The fast-paced nature of Kahoot! quizzes can lead to "surface learning", where students prioritize getting quick answers for points rather than deeply understanding the material [10]. Furthermore, the platform's format might not always allow for in-depth exploration of complex topics, potentially limiting students' ability to develop a thorough comprehension of the subject matter. Students without reliable access to mobile devices or the internet may be disadvantaged when using Kahoot! This can create unequal learning opportunities within the classroom. Furthermore, prolonged use of Kahoot! on screens can contribute to digital fatigue, especially if used extensively without breaks [23].

Recent research on Kahoot!'s impact on performance has shown various perspectives about its potential usage. According to Göksün and Gürsoy [9], Kahoot! has a more positive—though not statistically significant—impact on achievement and engagement compared to other groups. Quizizz had a lower impact than the control group in both areas. Despite these findings, pre-service teachers expressed positive views about gamification, noting issues related to MSA, reinforcement, entertainment, competition, infrastructure, and tools. Mada and Anharudin [15] pointed out that using Kahoot! in learning helps students recall material, increases their excitement and engagement, and encourages active participation and competition. It also enhances interest and MSA, particularly in Internet-related subjects, leading to improved knowledge. However, challenges include the lack of suitable devices and reliable internet connections for all students. A study by Malak [16] found that the experimental group that used Kahoot! experienced reduced stress and anxiety and improved self-efficacy and achievement compared to the control group. The findings suggest integrating Kahoot! into education can enhance both psychological health and performance.

Several recent studies have additionally investigated the effectiveness of Kahoot! in improving student engagement and achievement in mathematics education. For instance, Umboh et al. [25] conducted a classroom action research study focusing on elementary-school math scores. Their findings, based on a three-cycle intervention with 22 fourth-graders in Indonesia, suggest that Kahoot! can be a valuable tool. Student activity levels and learning outcomes improved significantly, with the average score reaching 81% by the final cycle. Prieto's [18] research investigated the effectiveness of Kahoot! in reducing student MSA and science anxiety and fostering greater engagement in secondary classrooms. Students responded to teacher-created quizzes using their mobile devices and received immediate feedback. Positive student evaluations suggest Kahoot!'s potential to enhance learning through interactive quizzes. Wahyuni et al. [19] investigated Kahoot!'s impact on understanding mathematical symbols among pre-service math teachers unfamiliar with them. The same study involved 100 participants who completed pre-tests and post-tests after using Kahoot! for symbol learning. Statistical analysis showed a significant improvement in understanding, highlighting Kahoot!'s potential as a tool for grasping mathematical symbols. Lastly, AlAli and Wardat's [24] research focused on the challenges of Kahoot! as a potential solution and examined its impact on achievement and student enjoyment. The findings contributed to understanding Kahoot!'s suitability for gifted students and provided insights into the broader use of gamification techniques in educational contexts.

While digital platforms like Quizizz, Mentimeter, and Socrative offer engaging features for K-12 students, Kahoot! can be considered as the most relevant due to the following reasons [9,10,21]:

- Accessibility: While all platforms offer varying degrees of accessibility features, Kahoot! stood out due to its user-friendly interface, mobile compatibility, and extensive support resources, making it more inclusive for a wider range of participants compared to Quizizz, Mentimeter, and Socrative.
- Economic cost: Considering the budget constraints of our project, Kahoot!'s free tier offered a robust set of features, making it a more cost-effective option compared to the paid tiers required for similar functionalities on Quizizz and Mentimeter. Socrative, while offering a free version, presented limitations in terms of question types and participant capacity compared to Kahoot!.
- Alignment with research objectives: Kahoot!'s emphasis on gamification and real-time feedback aligned more closely with our aim to enhance student engagement and knowledge retention than Quizizz, which primarily focuses on formative assessment. Mentimeter and Socrative, while offering interactive elements, did not provide the same level of engagement and immediate feedback as Kahoot!.

In summary, Kahoot! has the potential to positively influence learning performance by increasing engagement, motivation, and retention. Given its interactive and engaging nature, it is hypothesized that Kahoot! can redirect students' attention from passive screen consumption to active learning, thereby mitigating the negative impacts of excessive screen time. By incorporating gamification and providing immediate feedback, Kahoot! may promote a more balanced and productive screen use experience.

However, potential distractions, excessive use, and accessibility issues must be considered to maximize its benefits and minimize drawbacks. This study aimed to evaluate Kahoot!'s effectiveness in enhancing motivation and achievement among students creating instructional design content for mathematics education. By analyzing Kahoot!'s impact on both motivation and success, this research sought to address the issue of declining motivation and improve overall classroom performance. By implementing strategies to mitigate potential challenges, educators can leverage Kahoot!'s potential to design and develop learning tasks for all students.

3. Materials and Methods

3.1. Research Design

A quasi-experimental design was employed to investigate the causal relationship using a non-equivalent control group design with pre- and post-test measurements. Employing a non-randomized sampling approach with matched group sizes and gender distribution allow an effective control of potential confounding variables, thereby reducing the risk of biased findings [26]. Specifically, practical constraints or existing classroom structures also influenced group allocation, making the randomization imperfect in a STEM summer camp. This approach was chosen because it allowed for the comparison of outcomes between an experimental group (EG) using an alternative gamified platform and a control group (CG) receiving traditional instruction. The former group utilized Kahoot!, a digital platform offering dynamic visual aids and interactive content, while the latter group received traditional instruction through digital textbooks and PowerPoint slides with multimedia content. Participants in the experimental group utilized iPads, iPhones (with Kahoot! app version 6.07), or laptops (with the web platform) to monitor their rankings and evaluate their performance. In contrast, the control group solely employed laptops and tablets to view PowerPoint presentations (version 365).

To mitigate potential threats to the validity of this study, such as the "novelty effect", where initial excitement about Kahoot! could influence results, several measures were implemented. First, participants' prior experience with digital learning resources and mobile devices for self-directed activities was assessed. This included their familiarity with digital textbooks, multimedia presentations, and webcasts, which helped ensure that all participants, regardless of group assignment, had a similar baseline experience with educational technology. Second, this study aimed to moderate the novelty effect by carefully considering the participants' pre-existing familiarity with digital learning tools and adjusting the instructional design to account for these factors. By collecting detailed information on participants' prior experience with technology, this study aimed to control for any differences that could affect their engagement and performance outcomes.

Overall, the quasi-experimental design provided valuable insights into the effectiveness of Kahoot! compared to traditional methods while acknowledging the limitations inherent in non-randomized group assignments. The approach enabled a meaningful comparison of the two instructional methods while recognizing the potential influence of participants' prior experiences with digital learning tools.

3.2. Participants

This study recruited a sample of convenience consisting of one hundred and ten students (n = 110) who participated voluntarily and were non-randomly divided into two groups. One class (n = 55) was designated as the EG. During a STEM summer camp after the spring semester of 2023–2024, this group received instruction in mathematics using the Kahoot! platform. The remaining class (n = 55) served as the control group and received "traditional" instruction (PowerPoint slides with multimedia content).

The gender distribution was even, with 48% females (n = 53) and 52% males (n = 57). The average student age was 10.5 years old (range: 9–12 years, SD = 1.99). Most participants were 11 or 12 years old (combined: 66%), followed by 10-year-olds (26%) and 9-year-olds (8%). Participants categorized their daily computer usage frequency: 35% reported being light users, 50% reported moderate usage, and 15% identified as heavy users. This process provided insights into the extent to which the internet is integrated into their daily lives.

Additionally, the current study investigated the types of devices participants extensively used. Smartphones were the most popular choice (82%), followed by laptops (70%) and tablets (48%). This information helped establish the participants' comfort level with technology and their preferred methods of digital interaction (e.g., mobile learning vs. desktop learning). Finally, to assess existing experience with educational technology, this study measured participants' familiarity with educational platforms besides Kahoot!. This allowed for a more comprehensive understanding of how participants might approach and compare the intervention (Kahoot!) to other learning tools they might have encountered previously.

By gathering these details, this study paints a clearer picture of the participants' digital fluency and preparedness for engaging with the computer-supported learning environment. Students came from the school of education's diverse departments, focusing on instructional content creation in mathematics education. All participants did not have prior experience using Kahoot! or other relevant platforms in previous projects.

Before the intervention, the equivalence of the CG and EG was assessed using the independent-samples *t*-test. The results, presented in Table 1 along with corresponding analysis outcomes, indicated no statistically significant differences between the two groups' pre-test scores on the achievement and MSA scales. This suggests that before the intervention, the EG and the CG demonstrated similar baseline levels of achievement and MSA.

Table 1. Equivalence of CG and EG on pre-test measures.

Tool	Group	n	Mean	S.D.	T	$n-1$	p
Test	EG	55	10.43	6.87	0.622	53	0.577 *
	CG	55	11.30	7.11	0.622	53	0.577
MSA scale	EG	55	2.07	1.61	1.541	53	0.101
	CG	55	1.93	1.55	1.541	53	0.101

Note: * $p < 0.05$.

Equivalence in pre-test scores plays a critical role in experimental studies. This ensures that any subsequent differences observed in the post-test scores can be confidently attributed to the intervention, in this case, the use of Kahoot!, rather than pre-existing group disparities [26]. By establishing similar pre-test scores, this study strengthened the foundation for attributing any observed changes in post-test scores to the impact of Kahoot! on students' MSA and achievements.

Ethical approval for this study was obtained from the administrator of the STEM campus, ensuring that the research adhered to the ethical guidelines outlined in the Declaration of Helsinki and relevant national standards for research involving participants. Given the age range of the participants (9 to 12 years), special attention was given to the process of obtaining consent. Informed consent was first obtained from the parents or legal guardians of all participating students before the commencement of this study. This ensured that parents were fully aware of this study's objectives, procedures, and any potential risks involved. Additionally, assent was obtained from the child participants. Assent is particularly important when working with minors to ensure they understand the nature of their involvement.

The participants were informed about this study's purpose and their role in a way that was understandable and reassuring, ensuring that they felt comfortable participating. Both written and verbal assent were sought, depending on the individual student's comprehension level. This study maintained strict confidentiality and anonymity of all participant data. All personal information was anonymized, and participants were given the option to withdraw at any point without any consequence.

3.3. Procedure

3.3.1. Teaching Intervention

The teaching intervention for this study was designed to align with the mathematical content covered in the primary school curriculum, which typically encompasses Grades 5–10 and focuses on developing foundational math skills such as counting, basic arithmetic (addition, subtraction, multiplication, and division), fractions, decimals, geometry, and basic measurement. Each quiz was designed to assess students' understanding of key mathematical concepts, problem-solving abilities, and critical thinking skills. The quizzes were structured to align with the learning objectives outlined in the curriculum, ensuring coherence and relevance to classroom instruction. Instructors administered the quizzes during dedicated sessions, guiding students as needed. Students participated in the quizzes using various computing devices, while instructors monitored both administration and student progress. To evaluate progress in learning outcomes and MSA, both groups were closely monitored throughout the intervention. Instructors tracked student performance, participation rates, and response patterns. Regular assessments, including pre-tests and post-tests, were implemented to measure achievement and MSA scores.

Limiting device usage to desktop laptops and tablets for both the control and experimental groups was a strategy designed to control device-related variables and ensure that comparisons between the two groups remained fair and unbiased. Minimum specifications for the devices, such as screen size, processing power, and operating system, were established to ensure a consistent user experience across all participants. Additionally, brief training sessions were conducted for participants unfamiliar with the devices to minimize potential learning curves and reduce frustration, contributing to more reliable data collection. Device-related issues or challenges faced by participants were documented to identify any potential biases that might have impacted this study's outcomes.

The CG received traditional instruction using PowerPoint and/or digital textbooks. Although typically displaying static content, these materials also included interactive elements such as animations and multimedia. This could blur the lines between traditional and technology-enhanced instruction, potentially influencing this study's results. Therefore, it was crucial to detail device usage and the instructional context to differentiate the CG from the EG with Kahoot!. Furthermore, mathematical concepts were taught in the CG through lectures using static visual aids (e.g., charts, graphs, and models) projected in class. Students accessed digital readings from the course textbook on laptops and tablets, allowing for easy reading and annotation. Classroom activities, guided by the teacher, provided limited interaction through desktop computers and tablets. Independent study assignments involved PowerPoint presentations to reinforce lecture material, with instructor feedback provided through delayed written messages on tablets.

In contrast, the EG used Kahoot! to enhance engagement and interactivity. The instructor integrated Kahoot! into lectures to introduce new mathematical concepts and reinforce learning through interactive quizzes. Students accessed these quizzes using laptops, creating a more interactive and engaging lecture experience. The instructor managed and displayed quiz results instantly using a tablet. Kahoot! also enabled access to digital texts in a readable format, featuring dynamic visual aids and interactive elements that made the learning experience more engaging and visually stimulating. These aids were accessed on laptops, tablets, and smartphones, with the screen size and capabilities of each device enhancing the visual experience.

Students in the EG were also assigned additional Kahoot! quizzes to complete outside of class, providing ongoing engagement and practice opportunities. These quizzes were accessible on various devices (laptops and tablets), ensuring that students could complete their assignments conveniently, whether at home, in the library, or elsewhere. Kahoot! quizzes presented questions and answers in a game-like format, actively engaging students. Immediate feedback was provided through Kahoot!, allowing students to see their scores and correct answers right after each quiz. This instant feedback helped students address misunderstandings quickly and reinforced key learning points. Feedback was accessible on the same devices used for the quizzes, ensuring a seamless experience.

The use of multiple devices, such as a laptop for the main quiz interface and a smartphone for additional interaction, encouraged active participation and sustained interest by allowing students to interact dynamically with the material. By specifying the types of devices and their usage in different instructional contexts, this description provides a detailed understanding of how the EG engaged with Kahoot! in a flexible and interactive learning environment. The EG accessed Kahoot!, while the CG used PowerPoint on various devices, creating a versatile learning environment. Laptops were primarily used during instructor-led sessions and for completing quizzes that required larger screens and more detailed interaction. Tablets were used for both in-class activities and homework, providing a portable, user-friendly interface for interactive learning, quick access to quizzes, and instant feedback, especially useful for on-the-go learning and immediate participation in gamified activities.

3.3.2. Material Development

To understand better the design rationale of the material development of this study, the pedagogical underpinnings of Kahoot! for the EG and PowerPoint slides and digital textbook design materials were carefully considered. The alignment of the chosen question formats, difficulty levels, and multimedia elements with this study's goals and target learning outcomes has been clearly outlined.

The Kahoot! materials were developed with a focus on fostering critical thinking and analytical skills, aligned with this study's goal of enhancing problem-solving abilities. For instance, questions in Kahoot! were crafted to challenge students' problem-solving capabilities, e.g., through a multiple-choice question designed to test arithmetic skills: "*If you have 5 apples and you buy 7 more, how many apples do you have in total?*" This approach emphasizes the application of mathematical concepts in various contexts to promote deeper learning. In contrast, the CG utilized traditional PowerPoint slides that presented content in a more static format. These slides were structured to convey fundamental concepts and examples, such as through a slide that introduces multiplication with an explanation and a sample problem: "*If you have 4 groups of 3 apples each, how many apples are there in total?*"

While the PowerPoint slides or digital textbooks with multimedia content aimed to provide clear and direct instruction, they lacked the interactive and engaging elements found in Kahoot!. The integration of multimedia elements in Kahoot!, including images, videos, and audio clips, was designed to enhance student engagement and make learning more dynamic. Meanwhile, the CG materials incorporated basic multimedia, such as static images and brief video clips, to support content delivery but did not offer the same level of interaction. This deliberate design choice highlights the contrast between the experimental and control conditions and underscores the potential impact of interactive digital tools on student learning outcomes.

The key differences between the PowerPoint presentations and Kahoot! in terms of interactivity, learner control, and feedback mechanisms have been articulated. For example, Kahoot! provided interactive elements and real-time feedback, while the PowerPoint presentations were more static and did not include such features. Some of the most important for the EG using Kahoot! are the following:

- Animated avatars: The types of animated avatars available to players, such as characters, animals, and fantasy figures, have been specified. The contribution of these avatars to student engagement and motivation has been described. For example, avatars might include a cartoon cat that celebrates correct answers with a cheer or a superhero that gives encouragement for incorrect answers.
- Colored titles and text: The use of color in the question titles and answer options has been explained. The enhancement of readability and visual appeal through color coding has been discussed. For instance, different colors might be used to differentiate between answer choices, making it easier for students to follow along.
- Visual elements: The use of images, graphics, and other visual elements within the Kahoot! questions have been detailed. The support these visuals provided for content understanding and engagement has been explained. For example, a picture of a math problem might be used to illustrate a question about fractions.
- Sound effects and music: The incorporation of sound effects and music into the Kahoot! game has been described. The enhancement of the overall gaming experience and contribution to the learning environment through these auditory elements have been discussed. For instance, a sound effect for a correct answer might be a celebratory chime, while a motivational tune might play during the game.
- Question variety: Specific examples of different question types used within the Kahoot! games, such as multiple choice, true/false, open-ended, and picture choice, have been

provided. The use of these question types to assess various learning outcomes has been explained. For example, a picture choice question might ask students to identify which image represents a fraction.

- Feedback mechanisms: The visual and auditory feedback provided to players, including correct/incorrect answer animations, celebratory sound effects, and informative messages, has been described. This feedback is intended to guide and motivate students throughout the game.

Some of the most important design elements for the CG using PowerPoint slides and digital textbooks that were considered are the following:

- Slide content depth: The level of detail covered in each PowerPoint slide, including key concepts, examples, and visuals, has been specified. The support these details provided for instructional goals was described.
- Learning activities: Any accompanying activities or worksheets used in conjunction with the PowerPoint presentations have been outlined. The role of these activities in reinforcing the material presented has been explained.
- Teacher guidance: The level of teacher guidance provided during the control group sessions has been explained. The methods used by teachers to facilitate learning and support students with multimedia materials have been described.

On the one hand, students in the EG were given the option to select from a variety of animated avatars, including animals, superheroes, and fantasy characters. These avatars displayed dynamic reactions to players' answers, such as cheering for correct responses or providing encouraging messages for incorrect ones. Preliminary observations suggested that these features contributed to a more engaging and motivating learning environment.

On the other hand, the PowerPoint presentations for the CG did not include animated avatars or interactive elements. The multimedia aspects were limited to static images, videos, and animations designed to present mathematical concepts in a structured manner.

3.3.3. Data Collection and Analysis

To collect data from participants, all questionnaires were self-reported and delivered via email. Completion time was capped at 40 min to avoid categorizing participants as novices or experts, ensuring equal opportunity and unbiased responses regardless of experience. The main author also developed weekly lesson plans that guided the entire process. The data analysis encompassed several key steps and statistical techniques to thoroughly examine this study's variables. Initially, the subscales were translated into Greek, this student's native language, using the back-translation method proposed by Brislin [27]. The survey instrument utilized a 5-point Likert scale, with response options ranging from 1 (strongly disagree) to 5 (strongly agree). Likert-based analyses were conducted to evaluate the participants' responses. Overall scores were calculated by determining the proportion of correct responses across all assessments. Descriptive statistics, including means (Ms) and standard deviations (SDs), were employed to analyze these overall scores.

To assess the normality assumption of the data, the Shapiro–Wilk test was employed. The findings of this test are presented in Table 2.

To maintain participant anonymity, the authors, both computer science teachers, handled the data processing. Performance metrics were analyzed using an adaptive scoring method by Bridgeman and Cline [28], assigning 0 points for incorrect answers, 0.50 points for partially correct answers, and 1 point for correct answers. To facilitate interpretation, overall assessment scores per topic were calculated by averaging associated test question scores. These performance results were used exclusively for this study and did not affect participant grades. To analyze the learning experience, subscale scores were calculated by averaging responses to corresponding items. The statistical software IBM® SPSS® Statistics (version 27) was used to conduct the data analysis, ensuring a rigorous examination and accurate interpretation of the findings.

Table 2. Normality test.

Group	Time Point	Shapiro–Wilk Statistic	*p*-Value	Conclusion
CG	Pre-test	0.823	0.155	Normally distributed
CG	Post-test	0.856	0.299	Normally distributed
EG	Pre-test	0.877	0.144	Normally distributed
EG	Post-test	0.899	0.354	Normally distributed

3.4. Instruments

3.4.1. Demographics

To better understand the relationship between technology use and its impact on daily life, participants were required to complete a web-based form consisting of seven questions. This form highlighted several key topics reflected in this study:

1. Participant demographics: This study captured the age, gender distribution, and grade levels of the participants, including how these demographics influenced technology use.
2. Technology usage patterns: This study explored the frequency and intensity of daily computer usage among participants, categorizing them into light, moderate, and heavy users.
3. Device preferences: This study investigated the types of devices participants frequently used, such as smartphones, laptops, and tablets, and how these preferences impacted their digital interactions.
4. Digital fluency: This study assessed participants' comfort levels with technology and their familiarity with various digital platforms, focusing on their ability to engage with computer-supported learning environments.
5. Educational technology experience: This study examined participants' prior experience with educational technology platforms, excluding Kahoot!, to understand how their background might affect their engagement with new tools.
6. Readiness for technology-enhanced learning: This study evaluated participants' overall preparedness and ability to effectively use technology in educational settings, particularly in the context of instructional content creation for mathematics education.
7. Impact of no prior experience: This study considered the implications of participants not having prior experience with Kahoot! or similar platforms on their learning experience and engagement with the intervention.

The demographics form was designed to be completed within approximately 10 min. All responses remained anonymous, ensuring privacy while allowing for collective data analysis.

3.4.2. Student Performance in Mathematics

To understand how well the students aged 9–12 learned mathematics, pre-and post-tests were used, following guidelines from Terwel et al. [29], which focused on three main areas:

- Retention: How well the students remembered what they learned.
- Near transfer: How well the students could apply what they learned to similar problems.
- Far transfer: How well the students could use their knowledge in new and different situations.

Pre-test: Checking initial knowledge.

Before starting the treatment, students took a pre-test with multiple-choice questions on the following topics to understand what they already knew:

1. Arithmetic: Basic operations like addition, subtraction, multiplication, and division, and understanding number properties.

2. Geometry: Recognizing shapes and understanding basic measurement concepts like perimeter and area.
3. Fractions: Understanding fractions and how to work with them.
4. Introductory algebra: Solving simple equations and recognizing patterns.

Post-test: Evaluating learning in mathematics.

After the lessons, students took a post-test with more challenging problems. This test included the following areas:

- Retention: Questions to see how well the students remembered what they learned.
- Near transfer: Problems similar to those practiced during lessons to see how well the students could apply what they learned.
- Far transfer: New and different problems to test if the students could use their knowledge in unfamiliar situations.

The post-test topics included:

1. Arithmetic: Multi-step word problems involving various operations.
2. Geometry: Complex problems on shape properties and calculating the area of composite shapes.
3. Fractions: Real-life problems involving fractions.
4. Introductory algebra: Word problems with simple algebraic equations.

3.4.3. The MSA Scale

The current study employed the MSA scale developed by Sarıtepeci [12] to assess MSA levels among primary education students. This scale utilizes a 5-point Likert format to measure participants' agreement with statements related to multi-screen use. It comprises three sub-dimensions: Compulsive Behavior (8 items), Loss of Control (3 items), and Excessive Screen Time (4 items). Each subdimension captures a distinct aspect of multi-screen addiction.

However, for this study, a modified 10-item version of the MSA was administered. This version included 3 items from the Excessive Screen Time dimension, focusing on the duration of screen use. Additionally, 4 items from the Compulsive Behavior dimension were retained to assess the uncontrollable urge to use multiple screens. Finally, 3 items from the Loss of Control dimension evaluated difficulties in regulating screen time.

The relevance of the sample items in reflecting the sub-dimensions of the MSA scale plays a crucial role in establishing the content validity of the scale. Content validity refers to the extent to which the items on a scale adequately cover and represent the construct being measured. In the case of the MSA, the sub-dimensions are Compulsive Behavior, Loss of Control, and Excessive Screen Time, each representing a distinct aspect of multi-screen addiction.

1. Compulsive Behavior: Items within this subdimension assess the uncontrollable urge to engage with multiple screens. For instance, a sample item like "I feel the need to be constantly interacting with some type of screen" directly taps into the compulsive nature of screen use, capturing the essence of this dimension. The relevance of this item lies in its ability to measure the behavioral patterns associated with addiction, such as the persistent and compulsive engagement with screens despite potential negative consequences.
2. Loss of Control: This subdimension evaluates difficulties in regulating screen time. A sample item such as "I cannot control the amount of time I spend in front of any screen" is highly relevant, as it reflects the individual's struggle with self-regulation. This item contributes to content validity by addressing the core issue of loss of control, which is a hallmark of addictive behaviors. It ensures that the scale accurately measures the inability to limit screen time, a critical component of multi-screen addiction.
3. Excessive Screen Time: Items in this subdimension focus on the duration and extent of screen use. An example might be "I spend more time on screens than I intend to", which is relevant because it captures the excessive nature of screen engagement, often

leading to negative outcomes such as neglect of responsibilities or social isolation. The inclusion of such items ensures that the scale covers the dimension of excessive use, further strengthening its content validity.

Overall, the relevance of these sample items is critical in ensuring that each subdimension is adequately represented. By directly addressing the key aspects of multi-screen addiction, these items contribute to the content validity of the MSA scale, making it a comprehensive tool for assessing the various facets of screen addiction. This thorough representation of the construct across multiple dimensions allows the scale to accurately measure and differentiate between the different components of multi-screen addiction.

The internal consistency of the modified 10-item MSA was deemed acceptable based on a Cronbach's alpha coefficient of 0.83, based on Cortina's [30] recommendations. For illustration purposes, two sample items from the scale are presented: "*I feel the need to be constantly interacting with some type of screen*" and "*I cannot control the amount of time I spend in front of any screen*". These examples provide insight into the types of questions students encountered when taking the modified MSA.

3.5. Reliability and Validity

The reliability of the students' performance tests was assessed using two methods. Internal consistency was evaluated using the Kuder–Richardson 20 (KR-20) formula on a separate sample of 15 students to estimate the extent to which the test items measure the same construct. Test–retest reliability was determined by administering the test to a group of students twice, with a three-week interval, and calculating Cronbach's alpha to assess the consistency of scores over time.

The MSA scale was employed in this study. Pearson's correlation coefficient was used to examine the scale's correlational validity with teacher evaluations, a criterion considered a valid indicator of MSA in this context. Additionally, Cronbach's alpha was calculated to assess the scale's internal consistency. The reliability of the MSA scale was assessed using both Cronbach's alpha and McDonald's omega coefficients. While Cronbach's alpha yielded an excellent value of 0.93, indicating high internal consistency, McDonald's omega, which is generally considered a more robust estimate of reliability, particularly for ordinal data, provided a value of 0.91. Although both coefficients suggest strong reliability, the slightly lower omega value might indicate a more complex factor structure underlying the scale than initially suggested by Cronbach's alpha.

Table 3 presents the reliability coefficients (Cronbach's alpha, KR-20, and test–retest) for both the achievement test and the MSA scale. High values for all coefficients suggest strong internal consistency and reliability, implying that the instruments accurately measure their intended constructs.

Table 3. Reliability coefficients.

Authenticity Coefficient	Calculated Reliability Factor		
Compulsory	Cronbach's alpha reliability coefficient	Codder–Richardson reliability coefficient 20	Half-partition reliability coefficient
0.91	0.92	0.92	0.88

As shown in Table 3, the reliability coefficients for both the achievement test and the MSA scale were high (KR-20 = 0.92, Cronbach's alpha = 0.91 and 0.88, respectively), indicating strong internal consistency and reliability. These results suggest that both instruments accurately measure the intended constructs.

Table 4 presents the achievement test item difficulty and discrimination coefficients. Difficulty coefficients ranged from 0.33 to 0.71, and discrimination coefficients ranged from 0.21 to 0.86. Following established criteria by Al-Zboon et al. [31], the main researcher applied the following selection process:

- Items with discrimination coefficients between 0.19 and 0.39 were considered acceptable but might require revision to improve their ability to differentiate between high and low performers.
- Items with discrimination coefficients exceeding 0.35 were deemed strong and retained.
- Difficulty coefficients between 0.35 and 0.80 were considered acceptable.

Table 4. Difficulty and discrimination coefficients for achievement test items.

Items	Difficulty Coefficient	Discrimination Coefficient
1.	0.54	0.83
2.	0.46	0.26
3.	0.69	0.71
4.	0.46	0.46

Following these criteria, a 9-item achievement test was deemed suitable and included in this study.

3.6. Data Analysis

This section presents the statistical methods employed to address the RQs:

- MSA (RQ1): To assess the impact of Kahoot! on MSA, descriptive statistics (means and standard deviations) were calculated for MSA scale scores. Subsequently, a one-way ANCOVA (analysis of covariance) was conducted, following the recommendations by Lüdtke and Robitzsch [32]. Pre-test MSA scores served as the covariate to control for pre-existing differences in MSA between the EG and CG groups. This analysis aimed to identify statistically significant differences in post-intervention MSA levels.
- Students' performance (RQ2): Descriptive statistics (means and standard deviations) were calculated for achievement test scores. Another one-way ANCOVA was conducted, controlling for pre-existing achievement levels using pre-test scores as the covariate. This analysis aimed to identify significant differences in students' achievements between the groups after the intervention.
- MSA scale validity: Pearson's correlation coefficient assessed the construct validity of the MSA scale by measuring the interrelatedness of items within the scale.
- MSA scale reliability: Cronbach's alpha coefficient evaluated the scale's internal consistency. Moreover, the Kuder–Richardson equation (KR-20) provided further reliability assessment.

By employing these statistical methods, the current study aimed to comprehensively evaluate the effectiveness of Kahoot! in enhancing MSA and achievement among primary school students.

4. Results

The analysis of this study's findings aimed to identify the effects of Kahoot! on students' MSA levels in mathematics to answer RQ1. The independent *t*-test revealed no significant difference in pre-intervention MSA scores between the EG and CG ($t = -0.75$, $p = 0.456$, Cohen's $d = 0.23$). This small effect size indicates that the groups were similar in their MSA levels before the intervention, allowing for a more accurate assessment of the impact of Kahoot! on MSA in the post-intervention analysis.

The means and standard deviations for the MSA scale scores of both groups (EG and CG) were calculated, as shown in Table 5. The results revealed a notable difference in mean scores between the two groups. Students who used Kahoot! in their mathematics learning (EG) achieved a lower average MSA score (2.50) compared to those who received traditional instruction (CG), who had a mean score of 3.51.

Table 5. Post-achievement MSA scale.

Groups	*n*	Mean	SD	Adjusted Mean
CG	55	3.51	1.04	3.22
EG	55	2.50	0.95	1.99

Further analysis using a one-way ANCOVA, as detailed in Table 6, confirmed a statistically significant difference in MSA achievement between the two groups, favoring the CG. The eta-squared (η^2) value of 0.356 indicates a moderate effect size, suggesting that approximately 35.6% of the variance in MSA scores can be attributed to the type of instruction received.

Table 6. One-way ANCOVA (analysis of covariance) on the MSA scale.

Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Square
Pre-test	0.357	1	0.322	0.797	0.678	
Group	21.083	1	20.077	25.761	0.001 *	0.356
Error	41.717	47	0.675			
Total	66.979	49				

* $p < 0.001$.

These findings highlight that traditional instruction, as implemented in the CG, was less effective in reducing students' MSA levels in mathematics compared to the use of Kahoot!. The significant difference in mean scores and the moderate effect size emphasize the positive influence of Kahoot! in terms of lowering screen addiction. Although the CG exhibited higher MSA levels, suggesting greater screen addiction, Kahoot! effectively reduced MSA and significantly improved overall mathematical achievement. This demonstrates Kahoot!'s potential as an educational tool that not only enhances learning outcomes but also helps address screen addiction. According to this study's results, the CG had higher MSA levels, which suggests that traditional instruction was less effective in reducing MSA scores, not less effective overall. Therefore, the lower MSA scores observed in the EG do not directly imply a lack of motivation or engagement with the subject. It is of great importance to carefully consider the balance between using innovative tools like Kahoot! and ensuring that these tools effectively contribute to the intended educational outcomes.

The independent *t*-test revealed no significant difference in pre-intervention mathematics achievement scores between the EG and CG ($t = -0.71$, $p = 0.487$, Cohen's $d = 0.21$). This small effect size suggests that any pre-existing differences in mathematics achievement between the groups were minimal, ensuring that subsequent analysis can more accurately reflect the impact of the intervention on post-intervention outcomes.

To evaluate the impact of Kahoot! on students' mathematics achievement, Table 7 presents the analysis based on the post-application mathematics achievement scores of students in the EG and CG while controlling for any pre-existing achievement differences to answer RQ2.

Table 7. Post-achievement of the students' achievement test.

Group	Sample Size	Mean	SD	Adjusted Mean
EG	55	28.55	4.15	26.66
CG	55	18.55	4.22	17.88

The ANCOVA, set at a significance level of $\alpha = 0.05$, was employed to determine the statistical significance of the observed achievement disparities between the groups (Table 8).

Table 8. One-way ANCOVA for students' mathematics achievement test.

Source	Sum Squares	df	Mean Square	F	Sig.	Partial Eta Square
Pre-test	15.724	1	15.724	1.866	0.155	
Teaching strategies	1375.221	1	1533.410	177.689	0.001 *	0.655
Error	377.887	47	7.512			
Total	1881.322	49				

* $p < 0.001$.

Teaching strategies, as shown by the ANCOVA results, had a statistically significant effect on math achievement scores (F = 177.689, $p < 0.001$). This indicates that students taught with different strategies achieved significantly different scores on the math test, even after accounting for their pre-test scores. A substantial portion (65.5%) of the variance in achievement scores is explained by the different teaching strategies, highlighting their significant impact on student learning.

The statistical analysis in Table 8 revealed significant differences ($p < 0.001$) in the post-achievement test scores between the groups ($\alpha = 0.05$). Students in the EG, who were taught using Kahoot!, achieved a significantly higher average score (28.55) compared to the CG (18.55). Furthermore, the eta-squared (η^2) value of 0.655 indicates that approximately 65.5% of the variance in achievement scores can be attributed to the use of Kahoot!.

Overall, this study's results provide strong evidence that the use of Kahoot! in the EG resulted in a statistically significant improvement in students' achievement scores on the post-achievement test compared to the CG. The effect size, measured by eta squared (η^2), suggests that 65.5% of the variation in achievement scores between the groups can be explained by the use of Kahoot!, indicating a large and impactful effect on student learning achievements.

5. Discussion

This study investigated the impact of integrating Kahoot! as an instructional tool on K-12 students' achievements in mathematics and its potential influence on MSA. Specifically, it aimed to determine whether the interactive features of Kahoot! could enhance both academic performance and reduce screen addiction compared to traditional instruction using PowerPoint slides or digital textbooks.

In response to RQ1, the analysis of this study's findings revealed a statistically significant difference between the groups. The CG had a higher mean MSA score of 3.51 compared to the EG, which had a mean MSA score of 2.50. This result indicates that students in the CG underwent higher levels of screen addiction than those in the EG. Contrary to initial expectations, the data suggest that exposure to Kahoot! was associated with lower MSA scores, contradicting the common perception that traditional instruction might better manage screen time [9]. While the term MSA might imply a focus on screen use, in this context, it specifically relates to students' self-evaluation of their mathematical abilities. This finding stresses an important caveat, which is that the MSA does not directly measure motivation or engagement in the learning process [15,23,24].

Although Kahoot! is designed to enhance student motivation and engagement through its competitive and interactive features, this analysis focuses on its impact on screen addiction. The results of this study include the discrepancy between the lower MSA scores observed with Kahoot! and the significant improvement in mathematical achievement. The difference in effect sizes between MSA and mathematics achievement suggests that Kahoot! might have a more substantial impact on the latter. Therefore, the lower MSA scores observed in the Kahoot! group, alongside the significant improvement in mathematical achievement, suggest that Kahoot! not only reduces screen addiction but also enhances academic performance.

The variance between the MSA scale and its specific focus on screen addiction highlights the importance of selecting assessment tools that align closely with the constructs they aim to measure. This study reveals that while Kahoot! effectively reduces screen addiction (resulting in lower MSA scores) and enhances academic achievement, the tool used to measure these outcomes may not fully capture the constructs intended. This discrepancy challenges previous findings [9,15,25], which did not account for the dual impact of Kahoot! on reducing screen addiction while simultaneously improving academic performance. Even though Kahoot! is recognized for its ability to create a competitive learning environment, this study underscores its effectiveness in both reducing screen addiction and enhancing students' mathematical achievements, despite limitations in assessing self-assessed math skills directly. This finding emphasizes the need for researchers to diligently select and align assessment tools with the specific constructs they aim to measure to ensure reliable and meaningful results.

To answer RQ2, the one-way ANCOVA on the mathematics achievement test showed a statistically significant difference between groups (EG = 28.55 vs. CG = 18.55), suggesting a clear advantage for students utilizing Kahoot!, as previous studies have also advocated [17,25]. While Kahoot! reduced students' self-assessed MSA scores, it significantly enhanced their actual performance in mathematics, as evidenced by the one-way ANCOVA results. The computed F-value of 177.689 yielded a p-value of 0.001 at $\alpha = 0.05$, firmly establishing the statistical significance of the differences in achievement between the two groups. This finding underlines the robustness of Kahoot! as a tool for improving mathematical achievement, reinforcing its utility in educational settings where student performance is a primary focus. Moreover, Kahoot! significantly improved overall mathematical achievement, with a substantial effect size ($\eta^2 = 0.655$), suggesting a strong positive impact on learning outcomes. In other words, a substantial 65.5% of the variance in the performance achievement of participants in the EG on the post-achievement test can be linked to the use of Kahoot! Such a significant effect size is indicative of the powerful role that interactive, gamified learning tools like Kahoot! can play in educational settings, particularly in enhancing students' understanding and retention of complex subjects such as mathematics at a younger age. The observed positive influence on student achievement might be attributed to Kahoot!'s interactive design, competitive elements, and engaging approach. These features could potentially foster a deeper understanding and retention of mathematical concepts through several mechanisms. For instance, the immediate feedback provided by Kahoot! after each question not only reinforces learning but also helps students quickly correct misconceptions, thereby setting their grasp of the material. Kahoot!'s interactivity may enhance focus and active learning, while the competitive aspect could encourage students to review and consolidate mathematical knowledge in preparation for challenges [10]. Moreover, the use of Kahoot! might help students develop better study habits and time management skills, as the anticipation of competitive quizzes can motivate them to engage with the material more consistently and thoroughly, consistent with Nguyen et al. [17].

This study provides evidence for Kahoot!'s potential to improve students' mathematics achievement. The combination of lower MSA scores and significant improvements in mathematical achievement observed in the Kahoot! group suggests that Kahoot! not only reduces screen addiction but also enhances academic performance. Nonetheless, this study also acknowledges certain limitations, particularly the lack of measures for student interest and engagement, which are critical to fully understanding Kahoot!'s impact. Using validated instruments, such as the MSA scale, could help clarify Kahoot!'s influence and its potential effects on other cognitive and affective outcomes, such as problem-solving skills and confidence in mathematics [13]. Additionally, exploring the specific mechanisms by which Kahoot! facilitates learning—such as its competitive elements and immediate feedback—could provide valuable insights into its effectiveness. Understanding these mechanisms in greater detail could inform the development of more refined instructional strategies that maximize the benefits of gamified learning tools in mathematics education. A more comprehensive approach to evaluating Kahoot!'s effectiveness should consider not only student achievement but also their perceptions of the learning process. This approach would also explore how Kahoot! supports learning through its interactive features. By integrating these considerations, researchers can better understand how Kahoot! contributes to educational outcomes, considering both cognitive achievements and the broader behavioral patterns it may influence.

The findings of this study regarding Kahoot!'s positive impact on student achievement in mathematics align with previous research [16,18,24]. These studies suggest that Kahoot! facilitates deeper conceptual understanding and knowledge retention through its engaging and interactive design. The alignment of these findings with the broader body of research further validates the use of Kahoot! as an instructional platform, especially in contexts where active learning and student engagement are prioritized. Statistical analyses, including independent-sample *t*-tests for MSA and one-way ANCOVA for performance, revealed that students using Kahoot! exhibited lower self-assessed mathematical competence but significantly outperformed the control group in actual mathematics achievement, with a substantial effect size ($\eta^2 = 0.655$). These findings suggest that while Kahoot! enhances mathematical performance, it may not necessarily improve students' self-assessment of their mathematical abilities. The current study highlights the importance of aligning assessment tools with the intended constructs and recommends further research to explore the broader impact of gamified learning on student engagement and learning mechanisms. This comprehensive approach will provide a more complete understanding of Kahoot!'s effectiveness and guide the development of more effective instructional strategies in mathematics education.

6. Conclusions

In conclusion, this study demonstrates the importance of selecting appropriate measurement tools in educational research. The Kahoot! platform has significant benefits, but careful consideration must be given to the constructs being measured to ensure that outcomes are accurately interpreted. The findings showed a statistically significant difference in MSA scores, with the EG displaying lower scores than the CG, suggesting a positive effect on reducing screen addiction. Although Kahoot! contributed to lower MSA levels, it also significantly boosted overall mathematical achievement, with a notable effect size, indicating a strong positive influence on learning outcomes. This suggests Kahoot! not only effectively enhances mathematical performance but also reduces MSA levels. This study underlines the importance of aligning educational tools with desired outcomes and recommends further research to explore the broader effects of gamified learning on student engagement, screen addiction, and academic success.

The current study contributes to the growing body of literature advocating for the integration of digital tools in education, particularly those that actively engage students and foster a competitive yet supportive learning environment.

To expand our knowledge of how gamified learning tools can enhance education, this study proposes the following areas for exploration:

- Deeper exploration of MSA: Given the unexpected findings regarding MSA, future research should delve deeper into the relationship between gamified learning tools and overall screen time to examine the long-term effects of such tools on students' digital habits.
- Focus on motivational aspects: Research should explore the motivational factors underlying students' engagement with Kahoot! beyond competition. Intrinsic motivation and its relationship to achievement could be a fruitful area of investigation.
- Mechanism studies: To better understand how Kahoot! impacts learning, studies should focus on identifying the specific mechanisms at play, such as the role of immediate feedback, competition, and interactivity.
- Combination with other tools: Investigating how Kahoot! can be integrated with other instructional strategies or technologies to maximize its effectiveness would be beneficial.

- Qualitative research: Incorporating qualitative methods to capture students' perspectives on Kahoot! can provide rich insights into their experiences and learning processes.

7. Implications for Design and Practice

The findings of this study have significant implications for the use of interactive learning tools like Kahoot! in mathematics education, including the following:

- Enhanced student achievements: The improvement in mathematics education achievements for students using Kahoot! (EG = 28.55 vs. CG = 18.55) highlights the potential of gamified learning tools to significantly boost student performance. The large effect size ($\eta^2 = 0.655$) indicates substantial gains in performance, making these tools valuable for instructional strategies. This suggests Kahoot! not only aids in reinforcing mathematical concepts but also promotes a competitive learning environment that motivates students to excel. Such tools can be particularly effective in diverse educational settings where student engagement is a challenge, offering a structured yet enjoyable pathway to mastery.
- MSA and learning: This study revealed a significant improvement in MSA scores, suggesting that Kahoot!'s interactive and competitive format can effectively reduce students' multi-screen distractions. This positive correlation indicates Kahoot! may indirectly enhance learning outcomes. However, this study emphasizes the need for validated questionnaires and research instruments to accurately measure the impact of Kahoot! on students' motivation for learning mathematics. Without such tools, the interpretation of Kahoot!'s influence on student engagement and interest remains incomplete. Future research should explore the relationship between multi-screen attention and actual learning outcomes more deeply, ensuring that increased screen interaction translates to meaningful educational benefits.
- Instructional design content: Kahoot!'s interactive elements, real-time feedback, and competitive aspects appear to foster a deeper understanding and retention of mathematical concepts. These features align with best practices in instructional design, which advocate for active learning, immediate feedback, and student engagement as cornerstones of effective education. Educators should consider integrating such tools into their curricula to promote active learning and sustained focus. Immediate feedback helps students quickly address knowledge gaps, enhancing their learning process. Moreover, the competitive nature of Kahoot! can drive students to engage more thoroughly with the material, as they prepare for quizzes and challenges, thus reinforcing their learning outside of the classroom.

This study demonstrates the significant potential of interactive learning tools like Kahoot! to enhance students' achievements in mathematics education. It further emphasizes the role of well-designed digital tools in creating dynamic and interactive learning environments that can cater to a wide range of student needs and learning styles. However, it also highlights the need for precise measurement tools in educational research to accurately assess the impact of these innovations on student motivation and learning outcomes. By integrating engaging and interactive tools into the curriculum, educators can foster a more dynamic and effective learning environment for student engagement. To sum up, the findings suggest that, when used thoughtfully, tools like Kahoot! can transform traditional educational practices, leading to more meaningful and sustained academic success.

8. Limitations and Future Work

There are several important limitations to consider in this study. First, the reliance on self-reported data from Greek students introduces a potential for subjectivity, which could skew the results, particularly given the focus on elementary school contexts. Incorporating standardized assessments alongside Kahoot! activities would offer a more objective measure of learning outcomes. Second, this study's small sample size ($n = 110$) and limited demographic diversity constrain the generalizability of its findings. The observation that higher MSA scores do not necessarily correlate with increased motivation for math learning further complicates the interpretation of the results.

These limitations underline the need for additional research. Future studies should investigate the long-term effects of Kahoot! on student achievement and retention in mathematics, as well as its effectiveness across various subjects. Moreover, exploring the impact of different teacher training approaches and how educators adapt Kahoot! for diverse learning objectives and student needs would provide valuable insights. Understanding if Kahoot! provides a wide range of learning styles is also crucial. By addressing these gaps, future research could better illuminate Kahoot!'s potential to enhance student learning across disciplines and educational settings.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was first obtained from the parents or legal guardians of all participating students before the commencement of this study.

Data Availability Statement: The data used are publicly available and their citation is provided in the manuscript.

Acknowledgments: I would like to express my gratitude to all participants who voluntarily participated in this study.

Conflicts of Interest: The author declares no conflicts of interest.

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