Chapter 1 EduMath

In the current digital era, education is essential for effective learning strategies due to modern technology. As a result, the classroom is becoming a more familiar setting thanks to the addition of teaching aids like games, apps, and other multimedia materials. Along with its engagement, entertainment, and individualized experience, this type of education offers a livelier environment that piques students' attention more than academic subjects. Since young students are growing up in a technologically advanced world, incorporating educational games into the very early grade levels is a useful and efficient way to improve motivation and learning.

According to the United Nations Educational, Scientific and Cultural Organization (UNESCO), millions of children around the world lack foundational numeracy skills, with early math difficulties affecting long-term academic performance. Studies have shown that many young learners struggle with basic math concepts due to limited access to engaging and age-appropriate learning tools. According to research by Baroody et al. (2009), early exposure to interactive and playful math learning environments can significantly improve children's understanding of numbers, patterns, and problem-solving skills. However, traditional classroom methods often fail to address diverse learning styles, making math difficult and intimidating for many students at an early age.

According to the Philippine Statistics Authority (PSA) and reports from the Department of Education (DepEd), Filipino students in primary grades show low mastery levels in mathematics, especially in areas such as number operations and word problems. The National Achievement Test (NAT) results in recent years have reflected declining performance in math among elementary pupils, including those in Grade 1. Research conducted by the Philippine Business for Education (PBEd) also highlights that many public schools lack interactive learning tools and rely heavily on traditional rote learning and textbook-based instruction. This contributes to students' difficulty in understanding basic math concepts and developing problem-solving confidence at an early age.

EduMath aims to support both teachers and learners. EduMath uses lively graphics and engaging exercises to get pupils interested in learning math. For educators, it is an additional tool that enhances classroom education and helps pupils learn more efficiently. Additionally, the subsequent student progress and increased engagement in math instruction will benefit parents and possibly even school administrators.

E Learning methods for an early program usually drilled whether memorization or repetition of worksheets, indeed, the method may suit some kids, but unfortunately, many usually tend to stay aloof from the practice in the context of those who need kinesthetic or visual learning. Learning from textbooks doesn't have the interactivity or immediacy of feedback as online games, which in fact, make it more difficult for students to keep up with and retain interest in the subject.

Several challenges are in the way of enhancing early mathematics education. Lack of fun teaching materials, schools with limited access to technology, and difficulty in adapting to students’ various learning needs all come into play. Teachers may also experience hindering factors from innovating their teaching strategies due to time, training, or curriculum constraints. The end result is that many students now find themselves lacking basic math skills, a deficiency that compounds through to affect their long-term academic success.

To address these challenges, Edumath is an educational game designed to improve fundamental mathematical skills primarily among Grade 1 students. It comprises interactive lessons and mini-games and comes out with lively designs, appropriate for the younger ones. It is aimed at ensuring that mathematics doesn't intimidate as the children learn abstract concepts while playing. EduMath is encouraged to be used with automating scaffolding frameworks in teaching but will still entice students and get their brains "swelling'verses,' all while instituting better learning of math from a young age.

**Statement of the Problem**

This study aims to develop and evaluate EduMath, a game-based learning tool that enhances the math skills of Grade 1 students.

Specifically, the study seeks to answer the following questions:

What are the features and functionalities of EduMath?

How effective is EduMath in improving math skills among Grade 1 students?

What is the feedback from teachers and students regarding the usability and design of the game?

How does EduMath perform based on the ISO 25010 software quality standards?

**Objectives of the Study**

The main objective of this study is to design, develop, and evaluate EduMath, an educational game aimed at enhancing the basic math skills of Grade 1 students.

Specifically, the study aims to:

Design an interactive and child-friendly educational game tailored to the math curriculum of Grade 1.

Develop game features that focus on basic mathematical concepts such as counting, addition, subtraction, and number recognition.

Integrate engaging elements such as rewards, animations, and sound effects to increase student motivation and participation.

Evaluate the usability, effectiveness, and engagement level of the game through user feedback and performance data.

Assess the quality of the system using ISO 25010 standards in terms of usability, reliability, efficiency, and functionality.

**Significance of the Study**

This research is significant in promoting interactive and game-based learning as an alternative method for teaching math to young learners. It supports the improvement of education through innovation and technology.

Beneficiaries:

Students – gain better understanding and interest in math.

Teachers – receive support in delivering math lessons more effectively.

Parents – see improved performance and motivation in their children.

Schools – benefit from enhanced learning strategies and student outcomes.

**Scope and Limitation**

Scope:

This study focuses on the development and testing of EduMath as an educational game for Grade 1 students. The game covers basic math topics such as counting, number recognition, and simple arithmetic.

What can users do:

Students can play three different game.

Teachers can .

The system may track progress and provide feedback.

Limitations:

The game is designed only for Grade 1 math topics.

It may not be accessible in schools without proper technology.

Customization for different learning speeds is limited in the initial version.

**Definition of Terms**

EduMath – An educational game developed to enhance math skills among Grade 1 students.

Game-Based Learning – A method of teaching that uses games to make learning more engaging.

ISO 25010 – A set of standards used to evaluate the quality of software systems.

Math Skills – Basic arithmetic abilities such as counting, addition, and subtraction.

K-12 Curriculum – The education program implemented by the Department of Education in the Philippines.

Interactivity – The ability of a system to engage users through responsive activities or feedback.

**Chapter 2**

Review of Related Literature

This chapter introduces the review of literature that the researchers have found. This includes problems that were related to study and a more thorough evaluation of those problems. The researchers use the following keywords for the study, Games in Education, Game Based education for Primary Students, Cognitive Development and Mathematical Learning, Design Principles for Effective Mathematical Games, Technology Enhanced Learning for Primary Graders.

**Games in Education**

1.According to Raffaele Barretta (2023), gamification, also known as gameful design, involves the strategic application of game design principles, mechanics, and elements into non-game environments. This approach is often facilitated through digital platforms and aims to solve problems, increase engagement, and motivate individuals toward their goals. By fostering a gameful and interactive experience, gamification enhances users' perceived autonomy, competence, and relatedness. Its versatility has made it a valuable tool across various sectors, including education, business, marketing, and services, transforming traditional methods of engagement and enriching user experiences. The widespread impact of gamification underscores its potential to create value in multiple settings, making it a significant area of interest for researchers and practitioners alike.

2. According to Judy Julieth Ramírez Ruiz (2024), gamification the integration of game design elements into educational settings has emerged as a promising strategy to enhance school engagement in primary and secondary education. In a systematic review analyzing 90 interventions conducted between 2013 and 2023, the study examined how gamification influences students' academic, emotional, and behavioral commitment to learning. The findings highlight that while gamification can boost motivation and participation, a more comprehensive approach is necessary to fully realize its benefits. Specifically, the research suggests that evaluating school engagement should encompass a broader perspective, considering not only motivation and participation but also other factors and dimensions that contribute to the teaching and learning process. This holistic view is essential to effectively implement gamification strategies that align with educational objectives and enhance overall student engagement. The findings underscore the need for educators and researchers to consider the multifaceted nature of engagement when designing and assessing gamified learning experiences. By doing so, they can ensure that such interventions contribute meaningfully to the teaching and learning process.

3. According to Laura Leiss (2025), gamification has become a significant topic in educational research, increasingly applied in school lessons. However, the investigation of the conditions for and effects of its application on students is just beginning. Previous research on teacher-related conditions for the successful implementation of gamification often lacks a theoretical foundation. The current study aims to close this gap by using the theory of planned behavior to explore teacher variables that impact the use of gamification in class. The study surveyed 196 teachers (average age 41.8 years; 70.9% female) regarding constructs anchored in this theory through an online questionnaire. The results reveal that teachers’ attitude toward gamification, their perceived subjective norm, and their perceived self-efficacy regarding the implementation of gamification are important predictors of their intention to use gamification in class. However, none of these variables predicted the actual application of gamification in class. Instead, the study found mediating effects of teachers’ intention in the relationship between their attitude and behavior. In addition, moderating effects of self-efficacy were observed in the relationship between attitude and intention. Beyond these moderations, intention was found to be a direct predictor of behavior. The results provide important insights for promoting the application of gamification in schools and for designing teacher training measures.

4. According to Gene Klein (2021), the design challenges and limitations of gamification were analyzed through the context of the COVID-19 pandemic, with a particular focus on online or remote environments. These settings reveal a gap in the literature regarding evidence-based design recommendations and studies that specifically separate gamification from other pedagogical methods. The existing literature distinguishes between traditional games and gamification, noting that the latter primarily leverages entertainment to enhance academic performance. This emphasis on entertainment and its effects on both intrinsic and extrinsic motivation is explored. However, this dependence on entertainment can lead to unrealistic expectations, as the expectations associated with gamification may often be confused with those of actual games, particularly in educational contexts.

5. According to Stylianos Mystakidis (2023), play is a fundamental human activity that can ignite curiosity and promote skill development and behavioral change. Research in affective neuroscience has identified seven basic emotions that humans share with other mammals, including familiar emotions like fear, anger, and care. Notably, two emotions of particular interest in the educational context are exploration (seeking) and play, both of which are essential components of games. Games can be defined as rule-based systems that involve meaningful choices aimed at achieving desirable goals. Throughout history, games such as sports and board games have been integral to human civilizations.

6. According to Sophia Greenfield (2023), this paper examined 15 primary, peer-reviewed research articles focused on integrating game-based learning in elementary mathematics to enhance conceptual understanding. The aim of the paper was to provide teachers with insights on how to incorporate both digital and traditional games effectively, highlighting factors that contribute to successful implementation and improved conceptual comprehension. Key factors identified from the articles significantly influenced the effectiveness of game-based learning. In Chapter Two, traditional and digital games were categorized into two sections to evaluate the advantages and disadvantages of each approach. These benefits and drawbacks were compared in the Appendices to establish universal factors applicable to both traditional and digital game-based learning. These factors included the educational context, essential characteristics, and the role of the teacher. The research identified several gaps in the existing literature that could be addressed to enhance the credibility and further validate game-based learning as a valuable supplemental tool for instruction in elementary mathematics.

**Game-Based Education for Primary Students**

1.According to Manar S. Alotaibi (2024), game-based learning has become increasingly popular as a method for improving learning outcomes in children. This approach utilizes games to teach a variety of subjects and skills, fostering engagement, motivation, and enjoyment. In the context of early childhood education, game-based learning holds significant potential for supporting cognitive, social, and emotional development. This systematic review and meta-analysis aim to consolidate the existing research on the effectiveness of game-based learning in early childhood settings. The results indicate that game-based learning has a moderate to large impact on cognitive, social, emotional, motivational, and engagement outcomes. These findings suggest that game-based learning can be an effective tool for early childhood educators to enhance children's learning and development. However, additional research is necessary to fill the existing gaps in the literature. The implications of this study are relevant for educators, policymakers, and game developers who seek to foster positive child development and improve learning outcomes in early childhood education.

2. According to Edith Debrenti (2024), utilizing game-based learning (GBL), particularly digital game-based learning (DGBL), as a teaching and learning environment can serve as an effective pedagogical resource and strategy in the classroom to enhance mathematical learning. Effective manipulatives and games are essential for fostering mathematical understanding, as they assist students in constructing, reinforcing, and connecting various representations of mathematical concepts. High-quality games are especially beneficial for learners, offering them control and adaptability. These games are designed to align with cognitive and mathematical structures, promoting the development of connections between different pieces and forms of knowledge. Digital games can achieve similar effects. In this paper, we conduct a quasi-experiment using games specifically developed for this purpose, aiming to explore whether non-digital games produce different results compared to digital games. Our findings suggest that while students enjoyed the task-solving experience in both types of game-based learning, the outcomes can vary between non-digital and digital games.

3. According to Bolganay Kaldarova (2023), game-based learning is an innovative approach that leverages the educational potential of video games, particularly serious games, to enhance training processes and facilitate motivated learning for users. This study proposes the use of game-based learning for primary school students to aid in their understanding of computer science terminology, as they frequently engage in such learning methods. The research aims to evaluate the effectiveness of game-based learning in motivating primary school children to achieve academic success, involving fifty students divided into two focus groups over a 10-week period. Two types of measurements were employed to assess the benefits of game-based learning: a questionnaire addressing Impression, Usability, and User Interface, and tracking the downloading and uploading of homework assignments alongside academic performance. Approximately 90% of the students reported that game-based learning was beneficial for their studies and for retaining computer science terminology, expressing satisfaction with the functionality and ease of use of the learning tools. The findings provide valuable insights for educators, instructional designers, and researchers from the perspectives of implementation, design, and research.

4. According to Muhammad Sofwan Mahmud (2023), game-based learning (GBL) is a prominent trend in 21st-century education, with numerous studies investigating its impact on students' academic achievement. Integrating cognitive and affective domains into teaching strategies is essential, and this study aims to review journal articles from 2018 to 2022 that focus on the influence of GBL in mathematics teaching and learning on these domains. Utilizing a research methodology based on PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), the survey examined the Scopus and Web of Science (WOS) databases, identifying 773 articles related to GBL in mathematics. Ultimately, 28 open-access articles were selected for further evaluation based on study topic, design, technique, and analysis. The findings revealed that GBL positively impacts students' learning in mathematics, encompassing two types of cognitive domains (knowledge and mathematical skills) and five types of affective domains (achievement, attitude, motivation, interest, and engagement). These results are expected to encourage educators to implement GBL more effectively in the classroom. Since 2019, the number of studies related to game-based learning has increased, highlighting its influence on the cognitive and affective domains in mathematics education.

5. According to Chiara Fante (2024), the necessity to enhance science, technology, engineering, and mathematics (STEM) learning in secondary education is underscored by the ongoing exploration of innovative pedagogical practices, including game-based learning (GBL). This study aimed to identify the primary research themes related to game-based teaching and learning solutions in STEM education within secondary schools over the past decade, examining their evolution and key issues addressed in recent years through an analysis of scholarly publications based on word co-occurrence. After systematically selecting relevant publications, the titles and abstracts were compiled into a text corpus and analyzed using T-LAB software version 7.2.1.4 (2022). A preliminary visual exploration of keywords provided an overview of the research topics, followed by specificity analysis to track the evolution of themes based on the frequency of lemma usage across different publication years. The study also identified the main thematic clusters from the last three years to explore the most recent topics. The findings indicate a shift in focus over the past decade, moving from specific technologies and competitive aspects of games to understanding how GBL can enhance engagement, motivation, and comprehension of complex scientific concepts. The five key thematic clusters identified “Experience,” “Application,” “Validation,” “Emotion,” and “Programming” highlight a growing emphasis in recent publications on the experiential and emotional aspects of learning, the need for empirical studies, and the integration of computational thinking and coding into GBL. Overall, this study suggests that GBL has the potential to become a fundamental component of STEM education, adapting alongside pedagogical and technological advancements.

6. According to Muthia Rahman Nayla (2024), game-based learning is increasingly acknowledged as an effective method for promoting cognitive development in early childhood. This study investigates how it enhances children's problem-solving abilities, memory, and attention, as well as the perceptions of teachers and parents regarding its implementation. Employing a qualitative case study approach, data were gathered from 20 teachers and 15 parents through semi-structured interviews, classroom observations, and document analysis. Thematic analysis indicated that game-based learning fosters cognitive development by encouraging active engagement, stimulating curiosity, and enhancing problem-solving skills and information retention. Teachers emphasized the significance of creating meaningful play experiences, while parents noted improvements in their children's focus and memory. However, challenges such as insufficient teacher training, limited resources for play, and low parental awareness impede optimal implementation. The findings suggest that effective game-based learning necessitates well-structured activities, professional development for educators, and increased parental involvement. Addressing these challenges through targeted interventions could improve its effectiveness in early childhood education. This study offers valuable insights into the perceptions of teachers and parents regarding play-based learning in cognitive development and highlights the importance of collaborative efforts to maximize its potential. Future research should investigate its long-term effects and strategies for integrating it into various educational contexts.

**Cognitive Development and Mathematical Learning**

1. According to Hannah L. (2023), there is a growing consensus that numerical, executive function (EF), and spatial skills are essential for children's mathematical learning and development, with each skill theorized to connect to mathematics for different reasons. This suggests that these cognitive constructs may relate to mathematics through distinct pathways. The present study tests this hypothesis by involving 180 children aged 4 to 9 years, who completed a series of assessments measuring numerical, EF, spatial, and mathematical skills. Factor analyses indicated strong yet separable relationships among the children's numerical, EF, and spatial skills, with a three-factor model (representing numerical, EF, and spatial skills as separate latent variables) fitting the data better than a general intelligence (g-factor) model. Notably, EF skills emerged as the only unique predictor of number line performance, while spatial skills uniquely predicted arithmetic performance (specifically addition). Furthermore, spatial skills were associated with the use of more advanced addition strategies (such as composition/decomposition and retrieval), which in turn correlated with children's overall arithmetic performance. This indicates that children's strategy usefully mediated the relationship between spatial skills and arithmetic performance. Collectively, these findings offer new insights into the cognitive foundations of early mathematics, highlighting important implications for assessment and instructional practices in the future.

2. According to Lingling Wang (2024), this study examines the impact of math training on both mathematical and cognitive performance in 8- to 9-year-old students with low attention. A total of fifty-six students with low attention were randomly divided into a training group (n = 24) and a passive control group (n = 32). They underwent assessments for math problem-solving, calculation fluency, and PASS cognitive processing both before and after the training period. The training group participated in 3 days of training per week over a span of 21 days, utilizing the math modules from The Children’s Mathematics and Cognition Training Manual in Chinese. The findings revealed a significant improvement in the math problem-solving performance of the training group. Additionally, cognitive performance on the CAS-2, specifically in the planning and simultaneous processing tests, was enhanced for the training group. The study discusses the implications of these results, noting that the interpretability of the findings is limited by the absence of an active control condition.

3. According to Mei Tan (2023), this article suggests that basic cognitive skills can be nurtured and evaluated in early childhood education (pre-K) settings through a technology-based assessment approach. The Bilingual English Language Learner Assessment (BELLA) is specifically created for both monolingual (English or Spanish) and bilingual (English and Spanish) children, focusing on the development of cognitive skills alongside (pre-)academic knowledge. BELLA evaluates analytical, creative, and practical thinking in children aged 3 to 5 years through its distinctive content and delivery methods. It is recognized as one of the first tablet-based pre-K assessments aimed at measuring the cognitive skills essential for the Anthropocene era.

4. According to Lorenzo Esposito (2025), a significant body of research has explored the contributions of cognitive and emotional factors to math achievement; however, studies examining their combined effects in children are limited. This paper investigates the joint influence of cognitive abilities and math anxiety on math achievement in a sample of 135 seventh-grade students (54% male, age = 12.79, SD = 0.47). Math achievement was assessed using a validated paper-and-pencil test, while higher-order cognitive abilities were evaluated with a PMAs test. Working memory was measured through two verbal and two visuo-spatial experimental span tasks, and inhibitory control was assessed using three computerized tasks adapted from the classic Stroop, Flanker, and Simon tasks. Math anxiety was evaluated with the AMAS questionnaire. A series of correlation analyses and path models were performed to understand the intricate relationships among these factors. The correlations indicated a positive relationship among cognitive abilities and a negative correlation with math anxiety. Path analysis results revealed a strong effect of higher-order cognitive abilities on math achievement (β = 0.44, p < .001) and underscored the mediating role of working memory between math anxiety and math performance (β = −0.04, 95%CI [−0.11; −0.00]). In contrast, inhibitory control did not appear to significantly influence this relationship (β = −0.03, 95%CI [−0.08; 0.00]). These findings are discussed in the context of existing theoretical frameworks, suggesting that interventions aimed at reducing math anxiety could enhance math achievement.

5. According to Zhengqing Lee (2025), early mathematical and vocabulary skills are essential foundations for academic success, yet the mechanisms behind their development are complex. This study investigates the influence of parents’ education, children’s attentional control, and learning approaches as predictors of kindergarteners’ performance in mathematics and vocabulary. Utilizing a sample of 149 children aged 60 to 72 months in Shanghai, China, the researchers conducted a path analysis to examine both direct and indirect relationships among these factors. The findings reveal that parental education indirectly predicts math ability through children’s learning approaches and attentional control, highlighting the importance of both cognitive and behavioral pathways. In contrast, vocabulary development is directly affected by parental education and learning approaches, indicating different developmental trajectories for math and language acquisition. These results underscore the interconnectedness of cognitive, behavioral, and environmental factors in early academic performance. The implications for early childhood education stress the necessity for targeted interventions that engage parents in creating language-rich and cognitively stimulating environments while also supporting children’s motivation, persistence, and attentional skills.

6. According to Pedro Flores (2023), there is evidence supporting a connection between motor and cognitive development. Research indicates that among various motor skills, fine motor skills play a crucial role in enhancing mathematical performance in preschool children. Given that this is a sensitive period for motor skill development, insufficient physical activity during this time can hinder growth and contribute to weight gain and obesity. The objective of this study was to examine the relationship between mathematical skills, motor skills, physical activity levels, and obesity. The sample included 62 preschool children (32 males) with an average age of 4.63 ± 0.81. Mathematical skills were assessed using the Weschler Preschool and Primary Scale of Intelligence Revised Arithmetic Test, while fine motor skills were evaluated through the “Adapted Threading Beads Test” and the “Adapted Visuomotor Integration Test.” Gross motor skills were assessed using the Movement Assessment Battery for Children-2, Band 1, specifically the “Aiming & Catching” and “Balance” tests. Physical activity levels were measured with the “Preschool-age Physical Activity Questionnaire,” and obesity was determined using the body mass index. The results showed that only fine motor skills related to visuomotor integration were included in the multiple linear regression model (F < 0.001; r = 0.464; R2 = 0.215; p < 0.001), while gross motor skills, physical activity levels, and obesity were excluded. This indicates that mathematical skills were directly and significantly influenced only by visuomotor integration. Furthermore, visuomotor integration was positively and significantly associated with gross motor skills (r = 0.269; p < 0.05) but not with physical activity levels or obesity. Therefore, gross motor skills may enhance visuomotor integration directly, which in turn could indirectly improve mathematical skills. The findings suggest that implementing structured physical activity programs could positively impact mathematical performance.

**Design Principles of Effective Educational Math Games**

1.According to James Russo (2023), non-digital games are often utilized to enhance primary mathematics instruction. The literature suggests that to ensure a mathematical game is educationally valuable, it should adhere to specific principles, such as balancing skill and luck while maintaining a central mathematical focus in gameplay. However, there is a lack of research from the teachers' perspective regarding the specific characteristics of mathematical games that indicate their value for supporting learning and the likelihood of teachers using these games with students in the future. To address this gap, the current study engaged 122 educators in completing an online questionnaire that included 20 Likert-scale items aimed at assessing the characteristics of educationally-rich mathematical games (CERMaGs) aligned with six previously identified 'good practice' principles, in relation to a specific game of their choice. Educators evaluated a diverse array of mathematical games (n = 53). On average, they rated their selected game as highly valuable for supporting mathematics learning and expressed a strong likelihood of using it with students if given the chance. The findings indicated that educators placed particular importance on characteristics such as the game's appropriate level of challenge, engagement, enjoyment, adaptability for different learners, and potential for broader mathematical inquiry when assessing a game's educational value. Additionally, perceived student enjoyment, engagement, and the game's ability to facilitate rich mathematical discussions were significant factors influencing educators' likelihood of using a specific game in the future. The implications of these findings for enhancing classroom practices and teacher professional development are discussed.

2. According to Frutuoso G. M. Silva (2020), educational serious games are primarily designed to teach or train individuals on specific subjects. However, for a serious game to be effective, it must also be engaging enough to encourage players to play multiple times, thereby facilitating learning through play. The design of these educational games involves collaboration between game experts and pedagogical specialists, who must communicate effectively to create a product that is both educationally effective and enjoyable. While there are existing design frameworks to aid this communication, they often remain conceptual and fail to clearly differentiate between the fun aspects and the educational content, complicating the design process. This paper introduces a new practical methodology aimed at supporting the design process of educational serious games. This methodology is comprehensive, outlining all the essential steps required to define the learning mechanisms within an educational serious game, from selecting the topic to enhancing user experience. It also distinguishes the game's educational content from other mechanics that contribute to its enjoyment. Additionally, the paper provides practical examples to illustrate the application of this methodology.

3. According to Atanaska Bosakova-Ardenska (2024), this paper presents the development of an educational game featuring a graphical user interface that incorporates crossword principles. The game's architecture is structured using a three-layer software design. We created algorithms for the dynamic selection of words to facilitate crossword construction. The game is implemented in C# and comprises two primary modules: one for teachers and another for students. This game is utilized in the education of computer engineering students to evaluate their understanding of fundamental concepts in C/C++ programming. A survey was conducted to assess students' interactions with the game and their perceptions of gamification in the educational processes related to computer programming. The findings suggest that the use of the computer-based crossword enhances the educational experience throughout the semester and serves as an effective tool for motivating students to engage in their studies over the entire academic year.

4. According to Szilvia Szilágyi (2025), using digital and non-digital card games to teach mathematics is a well-established method, though their application in higher education, particularly for math, remains limited. This paper introduces Blue Yeti, an innovative non-digital card game designed to help Generation Z students understand the convergence properties of improper integrals through comparison theorems and the Cauchy–Maclaurin test. The paper details the game's development, rules, and mechanics as part of a multifunctional didactic framework. A two-year study involving 63 first-year computer science students assessed the game's effectiveness using a quasi-experimental design. Results indicated that the experimental group, which played Blue Yeti, achieved a mean score of 3.03 out of 6 on midterm exam problems, significantly higher than the control group's mean score of 1.78. Additionally, a mixed-method approach evaluated student attitudes towards the game, providing both quantitative and qualitative insights. Overall, the findings support the effectiveness of Blue Yeti as a learning tool.

5. According to Chronis Kynigos (2024), this paper explores how digitally enabled transformations in mathematics education can incorporate rationality within the framework of post-normal science and address wicked problems. It begins by reviewing the design and application of digital media in transformative mathematics education, providing a rationale for their use in tackling wicked problems. The discussion is framed epistemologically, questioning whether traditional scientific approaches can contribute to post-normal science. Focusing on the arguments surrounding wicked problem education, I examine a specific constructionist digital tool called ‘ChoiCo: Choices with Consequences,’ which aims to integrate mathematical concepts and enhance mathematical reasoning while addressing wicked problems. The final section analyzes student discourse to illustrate what reasoning might entail when engaging with these complex issues.

6. According to Douglas H. Clements (2023), the growing interest in early childhood mathematics education over the years has heightened the demand for empirically supported teaching strategies. However, there is still considerable disagreement on the most effective methods for teaching early math. This paper synthesizes empirical literature to outline research-based and validated pedagogical approaches for early math instruction. Most of these approaches share fundamental characteristics, such as a focus on children's interests and engagement, as well as content that aligns with their cognitive development. Learning trajectories serve as a particularly valuable framework, as they integrate educational goals, the development of children's thinking, and evidence-based teaching strategies. This framework aids teachers in understanding what children are doing, thinking, and constructing, while also providing instructional activities that promote deeper mathematical thinking. Additionally, it allows teachers to view instructional strategies from the child's perspective, creating meaningful and enjoyable learning experiences.

**Technology-Enhanced Learning for Primary Grades**

1.According to Ndhlovu B. Zanzini (2025), this study examined the integration of Information Communication Technology (ICT) in the teaching and learning of primary mathematics. The study aimed to identify the available ICT teaching and learning materials for mathematics in Pemba, explore how these technologies were utilized in instruction, and understand the challenges teachers faced in incorporating ICT to enhance lesson delivery. A case study design was employed, with purposive sampling used to select participants, including headteachers, deputy headteachers, senior teachers, and 24 teachers. Data was collected through interview guides, one-on-one questionnaires, and lesson observations, and analyzed using thematic analysis. The coding of transcripts revealed recurring themes and patterns that highlighted the experiences and challenges of the participants. The findings indicated that, aside from IRI radios and Let’s Read tablets, there was a limited availability of ICT and its integration in mathematics teaching and learning. The study recommended that the Ministry of Education provide training for primary school teachers on ICT integration, supply appropriate teaching materials such as interactive boards and math-related games, and ensure effective support and maintenance of the ICT infrastructure.

2. According to Lilla Korenova (2024), the integration of digital technology in education has become a crucial competency for primary school teachers, especially in mathematics, where innovative tools can significantly improve learning outcomes and student engagement. This paper explores the extent and nature of digital technology use among future mathematics teachers, focusing on tools such as dynamic geometry software (GeoGebra), e-testing platforms (like Kahoot), learning applications (such as Learning Apps), and immersive technologies including augmented and virtual reality. Our research analyzes the final portfolios submitted by graduating students from the Faculty of Education at the University of Ostrava in 2024. These portfolios, which encapsulate the students' educational strategies and experiences, provide valuable insights into the preparedness and innovative potential of future educators. Additionally, we gathered students' perspectives through questionnaires regarding their use of digital technologies in mathematics teaching. We specifically investigated how these candidates intend to incorporate digital technologies into their teaching practices and the innovative methods they propose to engage primary school students in mathematics. Through a qualitative analysis of 24 portfolios and a questionnaire survey of 15 students, we identified key trends and creative approaches in the application of digital tools. Our findings reveal not only the variety of digital technologies included in teaching strategies but also the depth of pedagogical integration, indicating a sophisticated understanding of how to effectively enhance learning environments. The results emphasize the importance of digital literacy in teacher education and suggest that current training programs are successful in equipping future educators with the skills needed to implement advanced technological tools. This study contributes to the ongoing discourse on digital competence in education, providing evidence of emerging trends and the transformative potential of digital technologies in primary mathematics education.

3. According to Hunhui Na (2024), while there is increasing interest in the technology-enhanced embodied learning approach in mathematics education and its pedagogical potential, much remains to be explored regarding its implementation in real classroom settings and its effect on student engagement in embodied learning activities. To address this gap, we present an embodied learning game that utilizes computer vision and Augmented Reality (AR) techniques. This AR game was implemented in fourth-grade classrooms to assess its impact on students' understanding of geometry, their attitudes, and their engagement patterns. Our analysis indicated significant improvements in students' geometry understanding from pre- to post-test, although their attitudes did not change. A multiple regression analysis of students' in-game logs and hand gesture data revealed that only the time spent on making-angle activities was a predictor of cognitive learning gains, indicating that not all hand gestures contributed meaningfully to students' learning. In addition to showcasing the pedagogical advantages of cost-effective AR-based embodied learning in classroom environments, our findings emphasize the need for careful design of embodied actions that are both educational and engaging.

4. According to Yen-Ting Lin (2022), mathematics is a fundamental subject in primary schools, as the concepts and skills learned are essential for solving real-life and professional problems. However, many mathematical concepts can be abstract for primary students, which may lead to low motivation and poor performance in learning mathematics. To tackle this issue, it is crucial to encourage students to review and apply mathematical concepts after instruction. In traditional mathematics classrooms, teachers often assign exercises for review and application following formal lessons, but these activities can diminish student motivation and negatively impact their learning outcomes. To address this challenge, this study implemented a technology-enhanced board game to assist teachers and students in teaching prime factorization within traditional mathematics classrooms. The goal was to use the board game to facilitate students' review and application of prime factorization concepts after conventional classroom learning, thereby enhancing their learning performance. To evaluate this approach, 22 primary students were divided into an experimental group and a control group for the study. The experimental group used the board game for review and application activities, while the control group engaged in traditional exercises. The results indicated that the proposed board game not only improved students' learning achievements in prime factorization but also enhanced their motivation and attitudes toward learning.

5. According to Ahmad Fazril Alias (2024), the integration of digital tools in teaching and learning mathematics has significantly transformed traditional instructional methods. This research conducted a systematic review of literature on the use of digital technology in the context of mathematics education, focusing on the types of digital tools employed and their effects. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which facilitated the identification of recent articles from two databases (Scopus and ERIC) based on specific inclusion criteria. The analysis revealed 13 articles published after 2022 that met the criteria for integrating digital tools in the classroom, including game-based applications. The findings from the content analysis indicate that digital tools can enhance students' learning outcomes, problem-solving skills, engagement, and exploration. Overall, these findings provide a deeper understanding of digital technology and its potential to influence the teaching and learning processes in mathematics education.

6. According to Dr. Asit Kumar Sen (2024), technology-enhanced learning (TEL) has revolutionized mathematics education through the integration of digital resources, interactive learning platforms, and AI-driven personalized learning strategies. This paper explores the development, implementation, and impact of technology on mathematics education, focusing on its role in improving student participation, conceptual understanding, and problem-solving skills. A variety of digital resources, such as gamification, virtual simulations, adaptive learning systems, and AI-based tutoring, have significantly transformed traditional teaching methods. The research examines online and blended learning approaches, assessing their effectiveness compared to conventional classroom instruction. Additionally, it addresses key challenges, including issues of accessibility, teacher preparedness, and the limitations of AI-powered learning platforms. The paper also discusses emerging trends, such as blockchain, metaverse learning, and data-driven analysis, that are reshaping the future of mathematics education. The findings suggest that while technology holds great promise for enhancing mathematics education, its successful implementation requires overcoming infrastructural and pedagogical challenges.