

# Online game-based learning in mathematics education among Generation Z: A systematic review

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## ABSTRACT

In contemporary education, game-based learning (GBL) has become a captivating instructional method applied across various academic subjects, including mathematics. The utilization of online GBL in mathematics education constitutes a segment of the activities that mathematics educators can employ during their lessons to teach students and enhance their educational progress. The primary goal of this study was to examine recent research endeavors involving the use of online GBL in mathematics education for Generation Z cohort. To achieve this objective, a systematic review (SR) was carried out to investigate the types of online games employed, analyze previous research methodologies, and explore the educational contexts relevant to mathematics education that align with the needs of Generation Z. An SR process was conducted to gather relevant articles from three databases, namely Science Direct, Scopus, and Springer. Full-text articles were meticulously assessed based on predetermined eligibility criteria. The review revealed many online games suitable for mathematics education, including Augmented Reality, Digital Inquiry Game, E-Rebuild, Math-Island Game, NanoRoboMath, Quizizz, and Wuzzit Trouble. The incorporation of online games in mathematics education offers numerous advantages.

**Keywords:** Generation Z, higher education, mathematics education, online game-based learning, primary school, secondary school, systematic review

## INTRODUCTION

The impact of technology and its corresponding media is a constant influence on the lives and existence of individuals (Hidayat & Wardat, 2023; Kannadass et al., 2023; Pellas et al., 2018). The dynamics of education have undergone a transformation, extending beyond conventional methods like whiteboards, textbooks, or papers. The evolution includes the incorporation of technology, such as the application of mathematics and online games. According to Bonner and Dorneich (2021), game-based learning (GBL) is defined as the method of student learning facilitated through games. Online GBL specifically refers to the utilization of the internet for both playing and learning. It cannot be denied that online GBL is one of the trends in teaching and learning, including mathematics. Due to the COVID-19 disease, the education government has announced all teachers and students will take online classes in their houses, respectively to avoid the outbreak. In this case, GBL plays an important role in education. Various methods exist within GBL settings for incorporating games into the educational landscape. These methods encompass utilizing pre-existing games for educational purposes, infusing gamified elements like scoring systems and leaderboards into conventional learning activities, development of tailor-made educational games, and combining multiple techniques. The application of gameplay in learning entails the integration of commercial or educational games as central instructional components, with educational objectives seamlessly integrated into the gaming experience. Gamification enriches conventional learning activities by incorporating game-like components to boost engagement, while educational game design involves crafting games with a specific focus on pedagogical goals. Hybrid methodologies combine these strategies, exemplified by combining commercial games with supplementary learning elements to reinforce particular educational objectives.

In mathematics education, integrating online GBL is one of the activities available to mathematics educators to instruct students and enhance the overall teaching and learning experience. Many instructors prefer to utilize various online platforms, including but not limited to Kahoot, Quizizz, and Quizlet, as well as other applications and digital video games, to captivate students' interest and foster a heightened engagement with mathematics. Vankúš (2021) found that numerous mathematics games were developed to enhance achievements in diverse domains, including problem-solving and algebra skills, geometry

skills, strategic and reasoning abilities, arithmetic, and critical thinking. Nevertheless, public comprehension and acceptance of online GBL in mathematics remain challenging. Most people assume that most online games contain violent content, which can affect children's thoughts, feelings, and behavior. They also consider that games and learning cannot be mixed because they think students will become addicted to games until their studies are affected.

Albano et al. (2020) indicated that GBL makes learning more attractive. Since most students think that mathematics is a boring subject, using online games will make students feel strange and what they want to try. Through curiosity, teachers can slowly change students' minds that mathematics is not hard. According to Pellas et al. (2018), they suggested that the use of GBL has the potential to address disinterest, enhance motivation, and promote engagement in a child's learning. Additionally, GBL has the capacity to impart new knowledge, particularly in the context of problem-solving. Moreover, GBL also brings new challenges to students because they like to play games as fun and explore new content through GBL.

On the other hand, using games emphasizes fun and cannot guarantee learning (Albano et al., 2020). If a secondary school student keeps losing at the game, it may cause addiction, low self-esteem, or aggressive behaviors. It may also affect the students' thinking if the online games are not designed properly. There are different opinions about this topic. Therefore, this study aims to fill the gap by systematically reviewing the literature to determine the effects of online GBL in mathematics education on secondary school students. Thus, a systematic review (SR) was conducted to provide new perspectives on the effectiveness of online GBL in mathematics education and correct the public's misunderstanding of online games. The kind of SR we use is a scoping review in which we provide an overview of the available research evidence. Through this study, the public can have a new view and change their mind about online games, especially GBL.

### Research Questions

1. What types of online games are employed in the utilization of GBL for mathematics education targeting Generation Z?
2. What research methods do previous researcher apply regarding to this topic?
3. What were the focus context of online GBL from the previous studies?

## LITERATURE REVIEW

### Online Game-Based Learning

If we merely talk about online games, practically every secondary school kid has heard of them. Parents and instructors will be prouder if they use these internet games to educate their children, particularly in mathematics. According to Albano et al. (2020), recent years have seen a surge in research by numerous scholars exploring digital games across diverse domains. These online games, with a longstanding presence, have been designed to aid secondary school students in effectively learning mathematics courses. Mavridis et al. (2017) pointed out that computer games are engaging due to their inclusion of elements such as challenge, curiosity, and fantasy. Furthermore, online gaming may include characteristics that make them potentially good educational instruments in addition to its sheer entertainment. As many games provide experienced students with updated knowledge and expertise, the notion of online GBL allows students to obtain and develop their knowledge connected to their school syllabus.

Building on earlier research, it is suggested that online GBL has the potential to facilitate meaningful learning experiences for students through play. According to Moon and Ke (2020), engaging in various in-game actions is believed to contribute to students acquiring a sense of knowledge. Being incredibly captivating and demanding are reasons students are drawn to online games that might help them with their learning processes. Students nowadays have become tired of their bulky books, so they are seeking games that are more pleasant for them but can also be beneficial if they select the proper game for them, which is where online GBL may occur. Each student has a unique aptitude and capability to reason and grasp a topic, including mathematics, which is sometimes considered a tough subject. The presence of this facility can aid secondary school students in their understanding of mathematics.

Online GBL also has some issues that will be highlighted: relationships among secondary school students' peer interactions, task efficiency, and learning engagement (Moon & Ke, 2020). Online GBL will also discuss linkages between secondary school students' peer interactions, task efficiency, and learning engagement (Moon & Ke, 2020). We felt these difficulties were significant because, as we're seeing, these features are noticed whenever students use online GBL as a medium of learning. The research revealed an adverse correlation between students' peer contact and task efficiency, implying that students might overlook the opportunity to share their work knowledge extensively with their peers. Additionally, the negative connection between peer interaction and learning engagement suggested that a minimal level of peer contact was more likely to foster meaningful and reflective learning during mathematics playtime (Moon & Ke, 2020). Moreover, the study found that a negative association existed between peer interaction and learning engagement, indicating that lower levels of peer interaction were more conducive to promoting meaningful and reflective learning during mathematics gameplay (Moon & Ke, 2020).

Moon and Ke (2020) indicated that the study findings are consistent with earlier research indicating that multitasking has a detrimental influence on learning. According to a recent study, when students are tasked with carefully assimilating new information within a mathematics game, increased interaction outside the game may lead to distractions due to the split-attention effect. This distraction, in turn, may contribute to lower levels of learning engagement (Moon & Ke, 2020). Individually progressing in the learning processes through games may cost the kids a lot since they may lose their capacity to communicate

effectively with their peers. Nonetheless, secondary school pupils should not just concentrate on the games that eventually force them to become hooked to those games.

Undoubtedly, online GBL offers numerous benefits and advantages for secondary school students. Albano et al. (2020) highlight that instructional games prove highly effective in teaching complex procedures as they

- (a) employ action over explanation,
- (b) cultivate personal motivation and satisfaction,
- (c) accommodate various learning styles and skills,
- (d) reinforce mastery skills, and
- (e) provide interactive and decision-making contexts.

Previous research also emphasizes the importance of identifying mathematical reasoning as an efficient problem-solving strategy, serving as a foundation for participants to transition from generic problem-solving to math-specific problem representation and resolution during gameplay (Ke, 2019).

Furthermore, according to Albano et al. (2020), GBL environments have a dual impact on both cognitive and affective levels. For instance, they facilitate effective assessment and improvement of elementary mathematics knowledge among students. Additionally, certain game-based environments designed for elementary school mathematics courses can significantly enhance student learning outcomes, self-efficacy, and motivation in the field of mathematics. It is essential to recognize that the emphasis on mastering cognitive and affective skills is not confined to primary school students but should extend to secondary school students as well, as it is integral to the ongoing process of self-development.

Moreover, educational games contribute to the development of students' competencies by engaging them in problem-solving, collaboration, and communication activities (Albano et al., 2020). While playing games, students can connect through online competitions, fostering a positive learning spirit as they strive to excel both in and outside the classroom. Engaging in online games not only enhances their problem-solving skills as they navigate various game levels but also promotes collaboration. Some online games offer opportunities for students to work together as a team, providing valuable lessons in teamwork. Additionally, communication activities within these games offer an enjoyable means for students to improve their soft skills. In summary, online GBL offers numerous advantages for students across various aspects of their development.

## METHODOLOGY

### Systematic Review

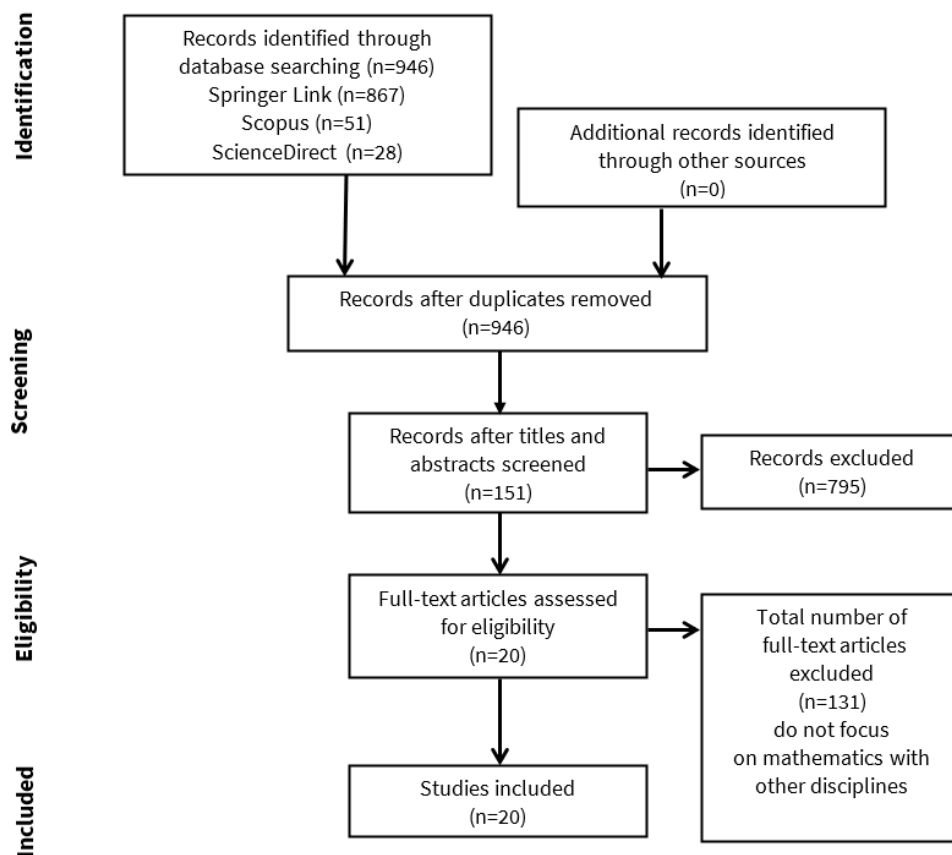
SR methodology involves the collection and organization of published articles based on systematic criteria for selection, aiming to mitigate reviewers' bias and enhance transparency in the process. Compared to traditional reviews, SR offers several advantages, including the incorporation of unique procedures. In this particular review, SR techniques were applied to three primary databases: Science Direct, Scopus, and Springer, known for their high indexing standards and international reputation. SRs adhere to a highly structured and standardized process, which can be broken down into several manageable steps. For this report, reviewers utilized PRISMA protocol as guidance (Figure 1), encompassing various aspects such as SR execution, eligibility and exclusion criteria, steps in the review process (identification, screening, and eligibility), and data abstraction and analysis. PRISMA framework comprises clearly defined stages that ensure precision in the research process and utility in the results. Notably, in recent research efforts, scholars have increasingly undertaken systematic literature reviews (SLRs) in the realms of STEM or mathematics education, employing PRISMA methodology for enhanced rigor and accuracy. These studies have been pursued by researchers such as Hidayat et al. (2022), Jabar et al. (2022), Man et al. (2022), Mohamed et al. (2022), and Zakeri et al. (2023).

### Identification

Three main search engines, Science Direct, Scopus, and Springer, were used to search for relevant articles. At the beginning of the process, the keywords ((“online game-based learning” OR “educational online game-based”) AND (“mathematics education” OR “mathematics”) AND (“Generation Z” OR “primary school” OR “secondary school” OR “upper secondary school” OR “lower secondary school” OR “higher education”)) were used to find the articles. These keywords ran separately for each database to provide a wide range of service-learning studies. We prioritized complete articles because these articles are considered to be a more reliable source of scientific information.

### Screening

There were 946 potential articles obtained at the first stage of keyword searching. Then, the reviewers refine the articles by considering the content type, discipline, published year, language, and access type. Only educational articles available in English and Malay, published from 2017 to 2021, will be accepted. The sample of this study is Generation Z, which refers to students in primary school, secondary school, or higher education. Only these criteria were considered because reviewers want the latest articles to review. Moreover, all the reviewers are studying mathematics education. Therefore, they are focusing more on articles about mathematics education. Articles were excluded if they did not meet the above criteria. There were 795 articles excluded through this process. Only 151 articles were left for quality assessment.



**Figure 1.** PRISMA flow diagram (Adapted from Moher et al., 2009)

### Eligibility

Following the compilation of all chosen articles, the reviewers employed selection criteria to sift through and eliminate studies deemed irrelevant. The process of study selection holds utmost significance in a systematic literature review, as underscored by previous studies (Moher et al., 2015). Adhering to the guidelines outlined by Moher et al. (2009), we devised a three-step approach for the article selection process. Firstly, we screened the titles of all retrieved research articles. Subsequently, we reviewed abstracts and screened the initially selected articles for eligibility. The final step involved a comprehensive full-text review to make the ultimate inclusion decision, evaluating the articles' suitability and alignment with our research objectives. Initially, 946 articles were identified from the three databases: Science Direct, Scopus, and Springer. Following the removal of duplicate entries across all three databases, 151 articles remained. These articles underwent scrutiny through the review of abstracts, resulting in the retention of 20 articles for a full-text review. Ultimately, these 20 articles, meeting all selection criteria, were chosen for inclusion in the review.

### Data Analysis

To address the research questions, a thematic analysis was conducted on the selected articles. Thematic analysis is a method used to identify, analyze, and report themes within the data. The process involves six phases:

- (1) becoming familiar with the data,
- (2) generating initial codes,
- (3) conducting an initial search for themes by collating the codes,
- (4) checking each theme to ensure the coded extracts work in relation,
- (5) defining and naming the themes, and
- (6) producing the report from the themes by relating them to the research question.

To ensure the credibility of the current work, two separate authors independently generated and categorized the themes. The information was grouped based on its relevance or similarity, contributing to a robust and comprehensive thematic analysis.

In the first phase, the reviewers familiarized themselves by reading the articles repeatedly. During the second stage, reviewers read all the selected articles and extracted any data related to the research questions. The reviewers can generate an initial search for themes based on the inductive coding frameworks at the third stage. The reviewers should practice relating any interests, similarities, and connections between the extracted data and the code. In the fourth phase, reviewers checked the themes to ensure the coded extracts worked in relation. Next, reviewers name and define the themes. In the last stage, reviewers write a report by relating the themes with the research questions. The coding results were organized and synthesized to answer the research questions.

**Table 1.** A summary & comparison of chosen papers

Author/year	Research question 1	Research question 2	Research question 3
Albano et al. (2020)	Digital inquiry game	Quantitative: Experimental research	Show how principles of game theory can be applied to design educational games that effectively teach mathematical concepts, aligning with students' cognitive preferences, & maintaining mathematical rigor
Bhagat et al. (2021)	Not applicable	Quantitative: Quasi-experimental design	Examine how an AR-based learning system enhances students' learning achievement in comparison to traditional text-based learning materials, specifically in context of understanding 3D geometry shapes
Bonner and Dorneich (2021)	-	Quantitative: Quasi-experimental design	Ways of gaming can help to engage middle school female students
Brezovszky et al. (2019)	-	Quantitative: Quasi-experimental design	Conduct an assessment to evaluate impact of a GBL environment on enhancing adaptive number knowledge & associated arithmetic skills among primary school students
Celik (2020)	-	Mixed method	Explore impact of various instructional methods related to geometry when implemented in a natural or outdoor setting
Halloluwa et al. (2018)	-	Quantitative: Quasi-experimental design	Examine effects of gamified mobile applications on tablet computers when integrated into a classroom setting
Hofman et al. (2020)	-	Quantitative: Quasi-experimental design	Examine how specific motivations related to mathematics influence performance of elementary students in an educational video game centered around mathematical concepts
Hulse et al. (2019)	From here to there!	Quantitative: Quasi-experimental design	Evaluate effectiveness of introducing number sense & algebraic principles at an early stage through utilization of from here to there! Elementary program
Kärki et al. (2021)	NanoRoboMath	Quantitative: Quasi-experimental design	Investigate how NanoRoboMath contributes to enhancement of students' conceptual knowledge of rational numbers, particularly focusing on representations of rational numbers, impact of operations with rational numbers, & understanding of density of rational numbers
Ke (2019)	Architecture-themed 3D epistemic game	Mixed method	Explore effects of engaging with a 3D, architecture-themed epistemic game on students' performance in mathematical problem-solving, & mental rotation tests
Ke and Clark (2018)	E-Rebuild	Mixed method	Investigation of how learners engage with such a system is crucial for research on mathematical learning & problem-solving
Ke et al. (2019)	-	Quantitative: Quasi-experimental design	Explore methods & degree to which engaging in architectural building & problem-solving through a simulation GBL platform, such as E-Rebuild, enhances mathematical practices among middle school students in an informal learning setting
Mavridis et al. (2017)	Not applicable	Quantitative: Quasi-experimental design	Examine influence of incorporating an educational game into mathematics education on students' attitudes toward subject
Moon and Ke (2020)	-	Mixed method	Connections between peer interactions, task efficiency, & learning engagement among middle school students during mathematics game activities.
Murillo-Zamorano et al. (2021)	-	Quantitative: Quasi-experimental design	Investigate how incorporation of gamification in an active learning environment influences students' skills, academic achievement, & overall performance
Nand et al. (2019)	-	Quantitative: True experimental design	Characteristics of popular computer games for children to enhance their learning
Pratiwi et al. (2021)	Quizizz	Mixed method	Ways to use games in mathematics learning
Sun et al. (2021)	Wuzzit Trouble	Quantitative: Quasi-experimental design	Ways students perceive mathematics scaffolded by teachers in a digital GBL classroom
Yeh et al. (2019)	Math-Island Game	Quantitative: Quasi-experimental design	Investigate impact of an island system on students' mathematics achievement, focusing on conceptual understanding, calculation skills, & word problem-solving.
Yung et al. (2020)	-	Quantitative: Quasi-experimental design	Innovative approaches for integrating traditional card games with QR codes to enhance learning outcomes

## FINDINGS

After applying the eligibility criteria, a total of 20 papers were selected for systematic analysis. **Table 1** provides a summary and comparison of the chosen papers. Hulse et al. (2019) introduced a mathematics game called from here to there! designed to teach foundational algebraic concepts. This game, playable on web-based or touchscreen interfaces, utilizes a "play-like" engagement with puzzle-based scenarios to enhance elementary school students' mathematical learning by emphasizing attentional tendencies. Quizizz, another online game, allows users to create and share quizzes. Pratiwi et al. (2021) found that students taking discrete mathematics courses using Quizizz perceived the learning experience as more interesting, making them more familiar with the material. Wuzzit Trouble, a tablet-based mathematics game, focuses on practicing and solving integer arithmetic problems (Sun et al., 2021). It aims to foster students' creative and critical thinking skills in mathematics. Additionally, Ke and Clark (2020) developed E-Rebuild, a 3D game, where players solve applied mathematics problems represented in multimodal forms to complete in-game tasks.

In Taiwan, the Ministry of Education supports online games for mathematics education, with Math-Island being a prominent example (Yeh et al., 2019). Math-Island is a virtual city with a knowledge map game offering over 1,300 learning tasks and more than 25,000 questions spanning grades one to six. It serves as a learning portfolio, recording students' learning processes and outcomes while monitoring and improving their learning status. Augmented reality (AR) is utilized for educational game-based mathematics learning, such as geometry (Bhagat et al., 2021). Students reported satisfaction with AR learning experiences, indicating increased engagement in learning activities. Characteristics that enhance primary students' learning in games include colorful images, real-life characters, and high definition (Nand et al., 2019).

Students prefer GBL in mathematics as it transforms the learning process into an enjoyable experience, altering their mindset about mathematics (Nand et al., 2019). GBL fosters a welcoming and motivated learning environment, encouraging students to seek help from teachers and collaborate to comprehend and apply the taught concepts (Halloluwa et al., 2017). Research indicates that learning mathematics through games consolidates knowledge, allowing students to combine, compare, and strategically choose different approaches (Brezovszky et al., 2019).

Furthermore, gamification in learning creates better active learning experiences in higher education without significant differences in academic results or student satisfaction (Murillo-Zamorano et al., 2021). Online GBL enhances task efficiency and learning engagement in problem-solving. Moon and Ke (2020) found that a low peer-interaction efficiency (PIE) group outperformed a high PIE group in completing tasks and learning engagement. The low PIE group focused on task-relevant gameplay, reflecting on math-related actions, leading to better performance. GBL also increases interest in STEM, as shown by Bonner and Dorneich (2021), who developed games to boost STEM interest and achievements.

Architecture-themed 3D epistemic games, such as Ke's (2019) E-Rebuild, improve students' mathematical problem-solving knowledge. Gamification of mathematics using a hybrid card game aids in mastering decimals, fractions, and percentages (Yung et al., 2020). Collaborative and social-based learning through mobile technologies enhances students' achievement in mathematics (Yung et al., 2020). Involving games in education helps students transfer knowledge to real-life situations (Celik, 2019). Mavridis et al. (2017) found that online flexible games become a teaching method, improving students' positive attitudes toward learning mathematics. Positive emotions and attitudes arise when students play games, reducing anxiety toward mathematics. Kärki et al. (2021) discovered that NanoRoboMath, while engaging players, had a small positive impact on students' rational number conceptual knowledge.

Hofman et al. (2020) suggested incorporating scaffolds into educational video games to help children interpret various aspects of the experience. Ke et al. (2019) highlighted that an epistemic simulation game allows players to role-play professionals, learning content-related skills and ways of thinking involved in professional practice. Albano et al. (2021) developed a Digital Inquiry Game to positively influence students' beliefs about their mathematical capabilities in problem-solving. Overall, GBL in mathematics emerges as a dynamic and effective approach to engage students, foster positive attitudes, and enhance learning outcomes across various mathematical concepts and skills.

## DISCUSSION

Online GBL can benefit pupils, particularly in the subject of mathematics. Among the effects that can be created is the ability to acquire new mathematical information. Many online GBL programs teach students, particularly youngsters, new concepts such as geometry information such as 2D and 3D forms. There are also online games that educate kids on money management methods for purchasing objects in the game that entail the use of addition, subtraction, division, and multiplication operations. Online games provide information and improve children's learning (Nand et al., 2019).

We totally support online GBL since it may aid students in several crucial aspects if utilized correctly. Because they participate in problem-solving, cooperation, and communication tasks, educational games help students enhance their abilities (Nand et al., 2019). Problem-solving, cooperation, and communication activities are among the crucial parts that students must achieve, and online GBL is an initiative that should be used to achieve these three things while also positively growing students' abilities. While there may be some bad effects, these are avoidable with control and regulated use. However, if online GBL is not managed, it might have a detrimental impact. Among them are the disregard of academic courses at school, the wasted time with excessive games, and the decreased effectiveness in talking with classmates or virtually. This can happen without parental or guardian oversight or monitoring while they play online GBL. Students' future work possibilities will be hampered if their academic performance and communication skills deteriorate. Nand et al. (2019) revealed that some children's attitudes about video games oppose their attitudes toward school-based learning. As a result, this sort of behavior should be modified gradually.

We discovered two shortcomings when reviewing prior researchers' works. The biggest constraint study we discovered was a dearth of papers from prior researchers who examined our issue "online GBL in mathematics education among Generation Z." As an outcome, we shifted the sample to a new school level. With the quick assessment of the sample, we were able to collect more than nine articles relating to our topic, for a total of 20 articles. This is one of our difficulties while performing an article review on this issue. In future studies, researchers should ensure that each topic has a lot of coverage and study so that our article review is more complete and of high quality.

Another restriction of the study is the nature of the research techniques. The majority of researchers conducted their study using a quasi-experimental design. Researchers prefer quasi-experimental designs because they might try to show a cause-and-effect link between an independent and dependent variable. It demonstrates that the sample size ranged from 12 to 79 participants. Using mixed methods research techniques is highly recommended since it incorporates qualitative and quantitative methodologies. However, each study requires a unique research strategy to process their data thoroughly.

## CONCLUSIONS

The research significantly contributes to practical knowledge in several key aspects. Through an SR encompassing 20 selected articles, the investigators identified numerous online games applicable in mathematics education, including Digital Inquiry Game, E-Rebuild, Math-Island Game, NanoRoboMath, Quizizz, and Wuzzit Trouble. The review highlighted several advantages associated with integrating online games into mathematics education. One notable benefit is the capacity of online games to make learning mathematics enjoyable for elementary school students, allowing them to engage in educational activities while playing games. Additionally, online GBL supports the development of creative and critical thinking skills in mathematics, offering opportunities for students to practice and solve integer arithmetic problems. Furthermore, the study underscores the potential of online GBL to enhance students' interest and achievement in mathematics, functioning as a dynamic tool for engagement. It is also recognized as a learning portfolio, documenting students' learning processes and outcomes.

Students felt satisfied with the learning experience and engaged more in learning mathematics. Besides that, students could comprehend the content taught and have a better experience, which is beneficial in the digital society. Online GBL can help students to complete the task efficiently in solving problems. Students were more attentive in solving the task given with math-related game actions. Not only that GBL can increase students' interest in being involved in STEM such as broadening their knowledge in solving mathematics problems. Education involving games helps students transfer knowledge to real-life situations and improve their positive attitudes toward learning mathematics. Online GBL is valuable and interesting for mathematics education. Students preferred GBL in mathematics, and they were able to learn better with online games. In summary, the review brought to light a diverse array of online games that can be effectively employed in the realm of mathematics education, with notable examples such as Augmented Reality, Digital Inquiry Game, E-Rebuild, Math-Island Game, NanoRoboMath, Quizizz, and Wuzzit Trouble. This rich selection of resources underscores the versatility of integrating online games into the mathematics curriculum. Including these digital learning tools in mathematics education not only widens the spectrum of teaching methods but also presents many advantages, including heightened student engagement, interactive problem-solving, and the potential for more dynamic and personalized learning experiences.

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**Ethical statement:** This study does not require any ethical approval since it is based on existing literature.

**Declaration of interest:** No conflict of interest is declared by authors.

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