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Secondary School Teachers' Awareness and Use of Educational Games and Online Collaborative Learning to Enhance Problem-Solving Skills in Mathematics in Edo State

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Abstract: *This study investigated secondary school mathematics teachers' awareness and use of educational games and online collaborative learning tools in Edo State, Nigeria, with the aim of exploring their role in enhancing students' problem-solving skills. A descriptive survey design was adopted, and purposive as well as stratified random sampling techniques were used to select 120 mathematics teachers across the three senatorial districts. Data were collected using a validated questionnaire and analyzed with descriptive statistics. The findings revealed low awareness of platforms such as Kahoot!, Quizizz, and Google Classroom, along with minimal classroom integration of these tools. Teachers reported limited training opportunities, inadequate technological infrastructure, and insufficient institutional support, which restricted their use of innovative strategies despite recognizing their potential benefits. The discussion highlighted that systemic barriers, such as rigid assessment-driven curricula and skepticism toward digital resources, hinder effective adoption. The conclusion emphasized that bridging the gap between awareness and practice requires more than individual training; it also demands curriculum flexibility, resource provision, and institutional incentives. Recommendations include targeted professional development that demonstrates practical classroom applications, curriculum reforms that support activity-based, technology-enhanced instruction, and supportive policies and infrastructure to empower teachers to effectively integrate educational games and collaborative platforms.*

Keywords: *Mathematics, Problem-solving Skills, Game Based Learning, Collaborative Learning*

Introduction

Mathematics is a science that plays an important role in learners' education and daily life in the 21st century. It helps humans analyze problems and surrounding circumstances, guiding them in prediction, planning, and identifying the most appropriate solutions. In addition, mathematics is a fundamental skill for learning subjects

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related to science and technology. For example, students with strong calculation skills are more likely to succeed in solving physics equations, analyzing chemical formulas, and writing computer programs. Consequently, mathematics is included in the core curriculum from the earliest stages of education across the globe (Yapatang & Titiworada, 2022).

Problem-solving is a central feature of mathematical activity and a major means of developing mathematical understanding. This suggests that problem-solving is an integral part of all mathematics learning. Through problem-solving, students learn to apply their mathematical skills in new ways, develop a deeper understanding of mathematical concepts, and experience what it feels like to think like mathematicians (Son, Darhim, & Fatimah, 2020). As a result, students can acquire new knowledge, address real-world problems, apply diverse strategies, and reflect on and monitor the problem-solving process.

The process of problem-solving requires the implementation of strategies that may lead learners to explore multiple ideas through developing and testing hypotheses. Prema and Sathiskumar (2021) argued that the goal of teaching mathematics is to equip students to solve problems effectively, thereby developing both their cognitive and affective domains to support problem-solving abilities. Strong problem-solving skills among mathematics students are reflected in their ability to resolve mathematical situations logically and effectively, which in turn enhances achievement. According to Madhu et al. (2015), one of the key components of education is problem-solving, as it strongly influences academic success. Since success depends largely on solving problems, problem-solving has been described as one of the most important components of human behavior. Students' academic achievement is therefore closely linked to their problem-solving capacity, which is increasingly recognized as a critical skill in contemporary society. Conversely, the lack of effective problem-solving ability in mathematics students may be attributed to teachers' instructional methodologies.

In response to these challenges, the integration of technology into mathematics education has gained considerable attention. The use of technological tools such as educational games and online collaborative platforms has been shown to improve student engagement, enhance conceptual understanding, and develop higher-order thinking skills.

According to Bonner and Dorneich (2021), game-based learning (GBL) is defined as a method of student learning facilitated through games. Online GBL specifically refers to the use of the internet for both playing and learning. It is undeniable that online GBL has become a growing trend in teaching and learning, including in mathematics education. GBL plays an important role in education, with various approaches to incorporating games into the learning environment. These approaches include utilizing pre-existing games for educational purposes, infusing gamified elements such as scoring systems and leaderboards into conventional learning activities, developing tailor-made educational games, and combining multiple techniques.

The application of gameplay in learning often involves integrating commercial or educational games as central instructional components, with learning objectives seamlessly embedded in the gaming experience. Gamification enriches conventional learning by adding game-like features to increase engagement, while educational game design focuses on creating games with specific pedagogical goals. Hybrid approaches combine these strategies, for instance by supplementing commercial games with additional learning elements to reinforce particular educational objectives.

In mathematics education, online GBL is one of the innovative strategies available to teachers for enhancing instruction and improving the overall learning experience. Many educators employ platforms such as Kahoot!, Quizizz, and Quizlet, along with other applications and digital games, to capture students' interest and foster greater engagement in mathematics. Vankúš (2021) found that numerous mathematics games were developed to enhance achievement in various domains, including problem-solving, algebra, geometry, strategic reasoning, arithmetic, and critical thinking.

Despite its potential, public understanding and acceptance of online GBL in mathematics remain challenging. A common misconception is that most online games contain violent content that could negatively influence children's thoughts, feelings, and behavior. Others believe that games and learning cannot be effectively combined, fearing that students might become addicted to gaming, which could, in turn, hinder their studies.

Albano et al. (2020) indicated that GBL can make learning more attractive, especially since many students perceive mathematics as a boring subject. By introducing online games, teachers can spark students' curiosity, gradually changing their perception and helping them view mathematics as approachable rather than difficult. Similarly, Pellas et al. (2018) suggested that GBL has the potential to address disinterest, enhance motivation, and promote engagement in students' learning. Moreover, GBL can impart new knowledge, particularly in problem-solving, while simultaneously challenging students, who often find enjoyment in exploring new content through games.

On the other hand, critics argue that an emphasis on fun in gaming does not guarantee learning outcomes (Albano et al., 2020). For example, if secondary school students consistently lose in educational games, this could lead to frustration, low self-esteem, or even addictive and aggressive behaviors. Poorly designed games may also negatively influence students' thinking. Thus, while GBL offers significant opportunities, it also raises important concerns, and opinions on its effectiveness remain divided.

Collaborative learning is defined as a group of learners working together by sharing ideas, solving problems, or pursuing common goals (Lahann & Lambdin, 2020). Although traditionally developed in classrooms through peer-to-peer discussions, technological advances have introduced new opportunities for collaboration, such as access to transcripts of previous discussions (Hammond, 2017).

The collaborative learning strategy (CLS) is a student-centered approach in which learners of different abilities work in small groups of two to five students, depending on the context, to gain knowledge and solve problems. Each learner in the group assumes responsibility and contributes actively to the learning process. Abdulwahab (2016) defined collaborative learning as a method where students of varying skill levels work in small groups, with each member expected to learn from the teacher while also supporting others in the group. Torre et al. (2017) described collaborative learning as encompassing a broad range of pedagogical strategies that involve collective intellectual work by students, or students and teachers together. Students typically work in groups of two or more, producing outcomes or jointly seeking insight, answers, or meaning.

Nkrumah (2021) argued that when properly managed by the mathematics teacher, collaborative learning—seen as a highly structured form of group work—emphasizes problem-solving, inquiry, critical thinking, and independent study, thereby helping students succeed in their mathematical learning. Students engaged in collaborative learning often experience deeper understanding, shifts in thinking, and the development of positive interdependence and accountability. The core advantage of CLS lies in its capacity to improve students' understanding of mathematical concepts and their problem-solving abilities through interaction and communication with peers. Akpan and Nkan (2022) emphasized that in CLS, group members can support each other with explanations, reminders, and questions, particularly when interactions are structured to ensure equitable participation. This can be achieved by assigning or rotating roles, requiring consensus in decision-making, or organizing activities that demand shared input. Supporting this view, Akinoso et al. (2021) noted that in CLS, both students and teachers share ideas, thereby enhancing comprehension, problem-solving abilities, and students' overall reasoning skills.

Research evidence supports the positive impact of collaborative learning on academic achievement. Olanrewaju (2019) found that collaborative learning techniques improved students' achievement in mathematics. Similarly, Niyonsaba et al. (2022) reported that students taught using collaborative learning outperformed those taught using traditional lecture methods in a chemistry topic on the classification of oxides in Rwanda. Fakomogbon and Bolaji (2017) discovered that CLS improved students' performance in mobile learning environments and their ability to solve think-aloud-pair problems. Abd Algani (2021), studying primary school students in northern Israel, found that CLS enhanced mathematical comprehension, solution fluency, versatility of methods, originality, and innovative thinking, all of which contributed to academic success. Likewise, Aku et al. (2022) observed that teaching basic science using a collaborative approach improved students' attitudes and achievement in the topic of energy in Nasarawa State, Nigeria.

With technological innovations, collaborative learning has expanded into digital spaces. Asynchronous discussions, for example, encourage articulation of ideas, peer feedback, problem-solving, and reflection on others' contributions. This shift has given rise to Computer-Supported Collaborative Learning (CSCL), a pedagogical approach that leverages computing devices to enhance learning through social interaction and tools such as simulations and visualizations, thereby improving students' conceptual understanding (Ludvigsen & Arnseth, 2017). Technology-based collaborative environments also support the development of problem-solving skills in mathematics by enabling reflective thinking, knowledge construction, and critical analysis. Platforms such as online forums allow students to articulate their reasoning and receive feedback, fostering deeper understanding and higher-order thinking.

Asynchronous discussion groups, in particular, are effective tools for promoting interaction and learning. They allow automatic recording of contributions, which students can revisit for reflection and teachers can analyze for assessment. These forums also provide several advantages: time for reflection and information searching before participation, reduced risk of off-topic discussions, equal opportunities for contribution, and the creation of learning communities where knowledge emerges from shared practices and collaboration (Lucas, Gunawardena & Moreira in Jacob & Sam, in Barana, Conte & Omegna, 2024).

Several studies illustrate the role of asynchronous collaboration in mathematics learning. A pilot study by Jacob & Sam (in Barana, Conte & Omegna, 2024) explored the promotion of critical thinking among first-year university mathematics students through asynchronous discussions. Findings revealed increased participation in later forums, although most posts demonstrated lower stages of critical thinking (clarification and evaluation), with higher-order stages (inference and strategy development) observed among only a few students.

Jacob (2012) examined the relationship between critical thinking (CT) skills and student performance in an engineering mathematics course. Asynchronous discussion forums (ADFs), integrated into the course, were used to assess CT using the CAIS model. Results indicated that students engaged in ADFs demonstrated notable improvement in CT skills—such as analysis, inference, and strategizing—and achieved higher mathematical performance compared to peers with limited forum engagement.

Similarly, Alshaye, Tasir, and Jumaat (2023) studied 120 eleventh-grade students in Riyadh, divided into control and experimental groups. The experimental group engaged in complex programming tasks through asynchronous collaboration in Facebook groups, fostering reflection and problem-solving at their own pace. The study concluded that online problem-based learning significantly improved students' problem-solving and programming skills, promoting autonomy and more effective learning.

Therefore, when thoughtfully integrated, GBL not only increases engagement but also provides students with authentic opportunities to practice and strengthen their mathematical problem-solving skills in dynamic and interactive ways. Likewise, through collaboration, learners are exposed to diverse perspectives and strategies, which further enhances their ability to approach mathematical problem-solving with flexibility, creativity, and deeper understanding.

Despite its importance, the teaching and learning of problem solving in mathematics, particularly in Edo State, Nigeria, continue to face significant challenges. Many students struggle with applying mathematical concepts to real-life problems, often due to rote learning methods and outdated instructional approaches. Traditional teaching strategies tend to emphasize memorization over understanding, thereby limiting students' capacity to engage in meaningful problem-solving. Therefore, This paper explores Secondary Teachers' Awareness and use of educational games and online collaborative learning to Enhance Problem-Solving Skills in Mathematics in Edo State.

Purpose of the Study

The purpose of this study is to investigate the level of awareness and use of educational games and online collaborative learning tools by secondary school mathematics teachers in Edo State, and how these tools contribute to the development of students' problem-solving skills. The aims to examine the relationship between the use of these innovative strategies and student performance, while identifying challenges and opportunities for integrating such technologies in the teaching and learning of mathematics.

Research Questions

The following questions were raised to guide the study.

1. What is the level of awareness among secondary school mathematics teachers in Edo State regarding educational games and online collaborative learning tools?
2. To what extent do secondary school mathematics teachers in Edo State integrate educational games into their classroom instruction?
3. For what purposes do secondary school mathematics teachers in Edo State use educational games and online collaborative tools?
4. What types of educational games and online collaborative learning tools have mathematics teachers implemented in their classrooms?

Methodology

This study adopt a descriptive survey research design. The target population will consist of all public and private secondary school mathematics teachers in Edo State. This includes teachers across the three senatorial districts: Edo North, Edo Central, and Edo South. A multi-stage sampling technique was employed to select 120 participants. A well-constructed and self-developed questionnaire titled "Teachers' Awareness and Use of Educational Games and Online Collaborative Learning Questionnaire (TAUEG-OCLQ)" Questionnaire was used to get the desired information from the teachers. The questionnaire was divided into three sections (A, B and C). Section A was for collection of information on personal data of respondents while Section B and Section C consisted of questions that elicited responses from the respondents, they were to tick as appropriate and write where necessary. The designed questionnaire was subjected to face validation by two senior lecturers. The reliability of the research instrument was determined using a split half test using the odd and even numbered items to form the two halves with a coefficient of 0.75, indicating that it is highly reliable. Responses from the questionnaire were analyzed using the descriptive statistics of frequency counts, percentages, means and standard deviation.

Result

Table 1:

Teachers' Awareness of Educational Games and Online Collaborative Learning Tools in Mathematics Instruction (Problem Solving)

Items	N	Mean	Sd.	Remark
I am aware of the use of educational games in teaching mathematics	120	1.70	1.11	Not Aware
I am familiar with the following educational games: Mathletics, Kahoot!, Prodigy, Sudoku, Math Bingo, Quizizz and DragonBox	120	2.32	0.75	Not Aware
I am aware of local or Nigerian-made educational games or apps for teaching mathematics (e.g., Ludo, etc.).	120	1.76	1.13	Not Aware
I have received formal training on how to use educational games in the classroom	120	1.45	0.96	No
I believe educational games should be part of the mathematics curriculum in Edo State	120	1.94	0.79	No
I am aware of online collaborative learning platforms for teaching mathematics,	120	1.70	1.10	Not Aware
I understand the concept of collaborative learning in an online environment	120	2.21	0.63	No

Table 1 revealed that teachers reported being not aware of educational games such as Mathletics, Kahoot!, Prodigy, Sudoku, Math Bingo, Quizizz, and DragonBox. They were also not aware of locally made educational games or apps, nor have they received formal training on using educational games in the classroom. Additionally, respondents showed limited awareness of online collaborative learning platforms like Google Classroom or Padlet and a low understanding of the concept of collaborative learning in an online environment (Mean = 2.21, SD = 0.63). Although a few teachers expressed the belief that educational games should be part of the mathematics curriculum (Mean = 1.94, SD = 0.79), the overall results reveal that teachers lack adequate exposure, understanding, and training regarding the integration of these tools in mathematics instruction. This finding suggests that teachers may not be fully prepared to utilize digital game-based learning and collaborative strategies effectively in mathematics classrooms, especially within the Edo State context.

Table 2:

Teachers' Use and Experience With Educational Games and Online Collaborative Tools in Mathematics Instruction (Problem Solving)

Items	N	Mean	Sd.	Remark

I use online collaborative learning platforms for teaching mathematics (e.g., Google Classroom, Padlet, Zoom breakout rooms, Microsoft Team)	120	1.62	1.12	Rarely Use
I have participated in an online collaborative training program or group for mathematics teachers	120	1.63	0.68	Rarely Use
I often use educational games in my mathematics classes	120	1.45	0.84	Rarely Use
I often use online collaborative tools in my mathematics instruction	120	2.13	0.44	Rarely Use
I have trained or guided other teachers on the use of educational games or collaborative tools	120	1.73	0.65	No
I am willing to learn more or receive training on how to better use educational games and online tools for teaching mathematics	120	1.70	1.11	No
I have received any recognition or positive feedback for your use of games or collaborative tools in your class	120	1.57	0.50	No

Table 2 shows that teachers reported that they rarely use online collaborative platforms such as Google Classroom, Padlet, or Microsoft Teams for teaching mathematics and seldom participate in online collaborative training programs. The use of educational games in mathematics classes was also minimal. Moreover, teachers rarely guide others in the use of these tools and have not received recognition or positive feedback for using them. Despite this, there appears to be some willingness to learn, though still rated low, implying a need for targeted capacity-building programs to boost teachers' confidence and competence in using educational games and collaborative technologies. These results highlight a gap between awareness and practical application, emphasizing the necessity for professional development and institutional support to integrate these digital pedagogies effectively.

Table 3:

Purposes for Which Teachers Use Educational Games and Online Collaborative Tools in Mathematics Instruction (Problem Solving)

Items	N	N of Item	Percentage	Remark
To introduce new topics	120	20	17.0	Rarely Use
To reinforce concepts	120	7	5.7	Rarely Use
As classroom assessments	120	0	0.0	Never Use
For group activities	120	16	13.0	Rarely Use
As a reward/incentive	120	0	0.0	Never Use
For group discussions	120	0	0.0	Never Use
For project-based learning	120	0	0.0	Never Use
For peer teaching	120	20	17.0	Rarely Use
For homework/classwork submissions	120	0	0.0	Never Use

Table 3 explores the specific purposes for which teachers employ educational games and online collaborative tools in mathematics problem-solving. The data show very limited use across all instructional purposes. The highest usage was for introducing new topics (17%) and peer teaching (17%), both categorized as "Rarely Use." Other purposes, such as reinforcing concepts (5.7%) and group activities (13%), were also minimally reported. Strikingly, no teachers reported using these tools for classroom assessments, rewards/incentives, group discussions, project-based learning, or homework submissions (0.0%). This implies that educational games and collaborative tools are underutilized in fostering interactive, student-centered learning environments. Teachers may be aware of potential benefits but lack the training, infrastructure, or motivation to implement them effectively in daily classroom activities.

Table 4:
Types of Educational Games and Online Collaborative Activities Utilized in Mathematics Instruction (Problem Solving)

Items	N	Item	%	Remark
Math-based quizzes (e.g., Kahoot!, Quizizz)	120	7	5.7	Rarely Use
Puzzle-solving games	120	0	0.0	Never Use
Simulation/problem-based games	120	0	0.0	Never Use
Board-style math games	120	0	0.0	Never Use
Group assignments via Google Docs or Microsoft Word	120	0	0.0	Never Use
Math problem-solving in breakout rooms	120	0	0.0	Never Use
Peer-to-peer math explanations	120	0	0.0	Never Use
Class math forums/discussion boards	120	0	0.0	Never Use

Table 4 identifies the specific types of educational games and collaborative activities employed by teachers. The results indicate near-total non-use of most listed activities. Only math-based quizzes such as *Kahoot!* and *Quizzes*(5.7%) were "Rarely Used." All other activities, such as puzzle-solving, simulation/problem-based games, board-style math games, group assignments via Google Docs, peer-to-peer explanations, breakout room problem-solving, and discussion boards—were never used (0.0%). This pattern demonstrates that teachers' instructional practices remain largely traditional, with minimal adoption of innovative, technology-mediated teaching tools. It further underscores the urgent need for teacher sensitization and hands-on training to increase the effective integration of educational technology in mathematics instruction.

Discussion of Findings

This study underscores the enduring challenges associated with integrating digital and collaborative tools into mathematics instruction, despite widespread recognition of their pedagogical potential. Across the four research questions, the findings consistently demonstrate that while teachers value the role of educational games and online collaborative platforms in enhancing learner engagement and problem-solving, their actual classroom application remains minimal. This discrepancy reflects a constellation of systemic, structural, and pedagogical barriers that impede the effective adoption of technology-supported instruction.

For Research Question **1**, the findings highlight the urgent need for sustained professional development and awareness initiatives. Teachers' low technological competence, the rigidity of existing curricula, and limited institutional support collectively constrain innovation in mathematics pedagogy (Vankúš, 2021; Albano et al., 2020). Addressing these issues requires not only targeted capacity-building programs but also comprehensive systemic reforms that promote digital literacy, curricular flexibility, and institutional accountability.

With respect to Research Question 2, the results reaffirm the importance of structured training, clear implementation guidelines, and supportive policy frameworks. Consistent with Pellas et al. (2018) and Albano et al. (2020), the persistent underutilization of digital and game-based learning tools reveals entrenched curriculum priorities and inadequate institutional investment. This finding underscores the need for policy-driven innovation, where technology integration is not peripheral but central to instructional planning and delivery.

The analysis of Research Question 3 reveals a distinct gap between teachers' awareness of digital tools and their capacity for practical classroom application. Barriers such as insufficient infrastructure, low confidence, and inadequate instructional design support (Niyonsaba et al., 2022; Aku et al., 2022; Ludvigsen & Arnseth, 2017) suggest that isolated training initiatives are insufficient. Rather, an integrated reform approach, linking professional learning, technological infrastructure, and institutional capacity, is essential for sustainable pedagogical transformation.

For Research Question 4**,** the findings identify additional barriers, including skepticism about the educational value of digital games and the dominance of assessment-oriented curricula. These align with the challenges documented by Barana, Conte, and Omegna (2024) and Alshaye, Tasir, and Jumaat (2023), who emphasize that without a paradigm shift toward experiential and inquiry-based pedagogies, innovation in mathematics education will remain superficial. Addressing these concerns necessitates practice-based teacher training, curriculum redesign, and investment in supportive technological infrastructure.

Taken together, the findings reveal that while teachers acknowledge the transformative potential of educational games and collaborative platforms, systemic impediments continue to limit their adoption. A multidimensional response, combining professional development, curriculum reorientation, supportive policy, and institutional incentives—is indispensable for advancing mathematics instruction toward a more student-centered, technology-enhanced model that fosters creativity, collaboration, and critical thinking.

Conclusion

The study concludes that mathematics teachers in Edo State exhibit low awareness and minimal use of educational games and online collaborative tools. This limited integration is primarily attributed to inadequate professional training, weak institutional support mechanisms, and insufficient access to technological resources. Although teachers recognize the pedagogical value of these tools in fostering engagement and enhancing problem-solving competencies, conventional teaching practices and assessment-driven curricula continue to dominate classroom experiences. Bridging this divide necessitates coordinated systemic interventions encompassing teacher professionalization, curriculum reform, and policy support. Through such reforms, mathematics education in Edo State can transition toward a more interactive, learner-centered, and technologically enriched paradigm that supports deeper cognitive engagement and sustainable learning outcomes.

Recommendations

1. The Ministry of Education and relevant educational agencies in Edo State should institutionalize continuous professional development programs that emphasize the pedagogical integration of educational games and online collaborative platforms in mathematics instruction.
2. Faculties and colleges of education should embed hands-on, technology-integrated modules within teacher preparation programs, exposing pre-service teachers to digital tools such as Mathletics, Quizizz, DragonBox, and collaborative platforms including Google Classroom, Padlet, and Zoom.
3. Collaboration between educators, software developers, and curriculum experts should be encouraged to design culturally relevant and pedagogically sound educational games tailored to the Nigerian classroom context.
4. The state curriculum should be revised to formally integrate game-based and collaborative learning models as recommended pedagogical strategies, accompanied by detailed guidelines and exemplars to support classroom implementation.
5. Teachers who successfully integrate innovative digital practices should be recognized, rewarded, and engaged as peer mentors to cultivate a culture of instructional innovation, collaboration, and professional learning communities.
6. A structured evaluation framework should be instituted to monitor the effectiveness of these initiatives, ensuring iterative refinement and evidence-based decision-making aimed at enhancing student engagement, creativity, and mathematical performance.

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