



Secondary school students' perceptions of their usage of artificial intelligence-based ChatGPT in mathematics learning

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(Received: 17 May 2024; accepted: 12 February 2025)

Abstract

This study addresses the integration of AI-based technologies in education, focusing on secondary school mathematics classrooms. As technology shapes the education landscape, understanding students' perceptions becomes crucial. This research explores secondary school students' views on integrating AI-based ChatGPT in their mathematics education. Employing a mixed-methods design, the study used purposive sampling to select 125 students from senior classes 1, 2, and 3 in two schools. Data were collected through a questionnaire with Likert scale items and semi-structured interviews. Quantitative data were analysed using descriptive statistics, while qualitative responses were thematically analysed. Results revealed students' multifaceted perspectives, highlighting benefits and concerns. Students valued ChatGPT's role in enhancing understanding and problem-solving but expressed reservations about its consistent use and potential limitations. Preferences for adaptive responses and customisation tailored to individual learning styles are evident. Recommendations include comprehensive training, enhancing ChatGPT's adaptability, fostering critical inquiry, addressing ethical considerations, and collaborative policy development.

Keywords: adaptive learning, AI-based ChatGPT, data analysis, mathematics education, mixed methods, student perceptions

Introduction

In recent years, artificial intelligence (AI) has emerged as a transformative tool in education, offering innovative solutions to enhance teaching and learning processes. AI technologies, such as machine learning and natural language processing, are reshaping how students interact with educational content, particularly in subjects like mathematics (Egara & Mogege, 2024a, 2024b; Polypotis & Pahos, 2024; Sun et al., 2024). Mathematics, often regarded as a challenging subject for many students, has been a focal point for educational reform, with AI offering opportunities to address persistent difficulties in comprehension, engagement, and problem-solving (Egara et al., 2022; Egara & Mosimege, 2023, 2024; Mosia & Egara, 2024a, 2024b; Mosimege & Egara, 2023; Okeke et al., 2025).

One of the most exciting advancements in AI for education is the development of generative AI tools such as ChatGPT. As a language model, ChatGPT has the ability to engage students in interactive dialogues, offer personalised assistance, and explain mathematical concepts in a human-like manner (Farhi et al., 2023; Govender, 2023). This technology promises to enhance the learning experience by providing instant feedback, enabling students to engage with mathematics at their own pace and in a more individualised way (Govender, 2023; Korkmaz Guler et al., 2024). However, the adoption of such tools raises important questions about their impact on student learning, especially in a subject as foundational as mathematics.

Despite the potential benefits of integrating ChatGPT into mathematics education, limited research exists on how secondary school students, particularly in Nigeria, perceive and interact with this AI tool. While studies have shown that AI-based tools can promote deeper understanding and retention of mathematical concepts (Wardat et al., 2023), there is a notable lack of exploration into students' actual experiences with ChatGPT in a classroom setting. Furthermore, while ChatGPT can provide personalised learning experiences, concerns about its accuracy, reliability, and potential to overshadow critical thinking skills have yet to be thoroughly investigated (Getenet, 2024; Patero, 2023; Pittalwala, 2023). These challenges underscore the need for more research into how secondary school students engage with ChatGPT in their mathematics education.

This study aims to fill this critical gap by exploring the perceptions of secondary school mathematics students in Nigeria regarding their use of ChatGPT. By examining students' attitudes, experiences, and the perceived benefits and limitations of ChatGPT as a learning tool, the research seeks to provide valuable insights into how AI can be effectively integrated into mathematics education. In doing so, it aims to inform future pedagogical strategies and enhance the use of generative AI tools in supporting mathematics learning in Nigerian secondary schools. This investigation is grounded in constructivist learning theory, which emphasises active student engagement, social interaction, and the integration of new knowledge with prior understanding. The following research questions guided the study:

1. How do secondary school students perceive the integration of ChatGPT in their mathematics learning journey?

2. What aspects of ChatGPT do students find most helpful in navigating their mathematics studies?
3. What challenges or reservations do students express concerning the incorporation of AI in their mathematics education?
4. What preferences and suggestions do students have regarding the integration of ChatGPT in their mathematics education?

Theoretical framework

This study is underpinned by the theoretical principles of constructivism, a pedagogical philosophy endorsing the active involvement of students in their learning journey. Rooted in the contributions of renowned scholars such as Piaget (1970), Vygotsky (1978), and Dewey (1933), constructivism asserts that learners construct their understanding by actively engaging with new information and experiences. At its core, constructivism embodies several key principles. Firstly, it advocates for active engagement, encouraging students to move beyond passive reception of information to explore, question, and make sense of concepts through personal experiences. Secondly, the theory underscores the significance of social interaction in learning, emphasising collaborative activities and discussions as catalysts for shaping understanding. Lastly, constructivism recognises the importance of building on students' prior knowledge and integrating new information into their cognitive structures.

Applying these principles to mathematics education, constructivism prompts educators to move away from traditional didactic methods. Instead, it advocates for interactive, student-centred approaches involving hands-on activities, problem-solving scenarios, and collaborative learning experiences. In tandem with constructivism, our study explores the integration of AI-based ChatGPT into mathematics education. ChatGPT, as an interactive and responsive tool, aligns seamlessly with the principles of constructivism. It facilitates a conversational interface, allowing students to engage in dialogue, ask questions, and receive immediate feedback—mirroring the active engagement and social interaction advocated by constructivism.

The integration of AI-based ChatGPT aims to amplify students' understanding through two critical dimensions. Firstly, it promotes interactive learning by providing a dynamic platform for students to interact with the system in a manner akin to engaging with a human tutor. This encourages students to pose questions, seek clarifications, and engage in a dialogue that mirrors real-world problem solving. Secondly, the integration supports personalised learning by leveraging AI's ability to adapt to individual learning styles and preferences. Tailoring responses to the unique needs of each student, ChatGPT provides personalised support, addressing specific challenges and reinforcing concepts in a manner that resonates with the learner.

Literature review

Integration of ChatGPT in education

Researchers have undertaken comprehensive studies to investigate the multifaceted impact of ChatGPT in educational settings in general, especially from students' perspectives. For instance, Ajlouni et al. (2023) conducted a study investigating undergraduate students' perceptions of the advantages and challenges of utilising ChatGPT in counselling and mental health education. They employed a descriptive quantitative approach, and the study included 210 respondents from the counselling and mental health programme at the University of Jordan who had experienced ChatGPT in their learning. The findings revealed that 81.9% of participants regarded ChatGPT as a beneficial learning tool. However, students reported encountering moderate challenges and concerns during its use.

In a parallel effort, Singh et al. (2023) focused on applying ChatGPT in academia to enhance teaching and learning activities. Their survey involved 430 MSc computer science students at the University of Hertfordshire, UK. The study aimed to capture diverse aspects of ChatGPT's employment in academia and its potential impact on students in various learning activities. While the findings suggested the usefulness of ChatGPT, the study emphasised the necessity for improved guidelines in its utilisation. Bonsu and Baffour-Koduah (2023) pursued an investigation into students' perceptions and intentions regarding ChatGPT in higher education. They employed a mixed-method approach, and their study found no statistical relationship between perception and the intention to use ChatGPT. Despite this, positive perceptions and intentions among students were reported, advocating for the integration of ChatGPT in education.

Furthermore, von Garrel and Mayer (2023) conducted a nationwide survey in Germany to analyse the use and characteristics of AI-based tools such as ChatGPT among students. The quantitative study, involving 6,300 students, revealed that two-thirds of participants had used or were currently using AI-based tools, with engineering, mathematics, and natural sciences students being the most frequent users. Naher et al. (2023) explored how university students in Bangladesh utilise ChatGPT, primarily focusing on its role as an AI-powered educational tool. A survey of 62 students from an engineering institution revealed that ChatGPT predominantly assists students in educational tasks such as homework assistance and test preparation, despite concerns about accuracy and potential overreliance. Elkhodr et al. (2023) delved into using the generative artificial intelligence tool ChatGPT in higher education through three case studies involving undergraduate and postgraduate ICT students. The findings indicated a positive perception of ChatGPT as a useful and enjoyable learning resource, with most students expressing a willingness to use similar AI tools in the future.

Shoufan (2023) conducted a two-stage study with 56 senior students in a computer-engineering programme, evaluating ChatGPT's capabilities and usability. The results highlighted students' admiration for ChatGPT's interesting and motivating features while acknowledging concerns about accuracy and the requirement for background knowledge. Yilmaz et al. (2023) explored university students' perceptions of ChatGPT, employing a

quantitative research approach with 239 students in the Science and Mathematics Education Program at a private university in Almaty, Kazakhstan. The study revealed an overall positive perception of ChatGPT among participants. Meanwhile, Valova et al. (2024) further delved into the impact of ChatGPT on education, focusing on high school and university students' perceptions and usage patterns. Their study revealed diverse perspectives on integrating ChatGPT into learning, emphasising the need for cautious AI integration to foster critical thinking and intellectual development.

Integration of ChatGPT in mathematics education

In recent years, the integration of advanced AI technologies, particularly ChatGPT, has sparked significant interest in revolutionising mathematics education. Patero (2023) spearheaded this exploration, leveraging ChatGPT to enhance personalised learning, interactive problem-solving, and dynamic engagement among students. His findings illuminated positive shifts in student attitudes, increased self-efficacy, and improved learning outcomes. Notably, Patero's research underscored ChatGPT's pivotal role in fostering collaborative learning environments, offering a glimpse into the transformative potential of AI in preparing learners for the challenges of an ever-evolving educational landscape.

Dasari et al. (2023) provided deeper insights into the role of ChatGPT in math teaching and learning, uncovering nuances in its effectiveness. Their findings highlighted the importance of a balanced approach, where ChatGPT supplements teacher guidance rather than replaces it, in light of concerns regarding overreliance and ethical implications. Meanwhile, Asare et al. (2023) further examined the interplay between student factors and ChatGPT's impact, investigating its influence on mathematics achievement, particularly considering students' interest in math. Their study echoed the call for cautious integration of ChatGPT in math education, emphasising its role as a complementary tool alongside traditional learning methods. In parallel, Wardat et al. (2023) aimed to examine the perspectives of students and educators on the use of AI in teaching mathematics, particularly after the launch of ChatGPT. Their qualitative case study underscored ChatGPT's enhanced math capabilities and potential to increase educational success. However, caution was advised due to limitations in understanding geometry and effectively correcting misconceptions.

The existing literature extensively covers the applications and perceptions of ChatGPT in various educational settings, including higher education. However, a notable gap exists in Nigeria, specifically concerning the lack of research on the attitudes and experiences of secondary school mathematics students regarding ChatGPT, especially at the secondary school level. Despite the technology (AI-based ChatGPT) being relatively new, this research aims to address this gap by focusing on the perceptions of secondary school mathematics students in Nigeria, contributing valuable insights into the challenges and potentials of integrating ChatGPT into their learning experiences. This study aims to fill a significant research gap by exploring the perceptions of secondary school mathematics students in Nigeria regarding their interaction with AI-based ChatGPT. The overarching goal is to establish a foundation for future research on the impact of advanced AI technologies in mathematics education at the secondary school level in Nigeria.

Method

Design of the study

This study employed an explanatory sequential mixed-methods design, combining both quantitative and qualitative approaches to explore secondary school students' perceptions of using AI-based ChatGPT in mathematics learning within the Nsukka Education Zone of Enugu State, Nigeria. The quantitative component involved the collection of numerical data, providing a broad overview of students' experiences and challenges with ChatGPT in mathematics education. This was followed by the qualitative component, which allowed for an in-depth exploration of students' perceptions, offering deeper insights into how ChatGPT impacts their learning journey in mathematics. The integration of both components provided a comprehensive understanding of the subject, with the quantitative data helping to identify general trends and the qualitative data allowing for a more detailed examination of students' views and experiences.

Population of the study

The study population comprised secondary schools within the Nsukka Education Zone of Enugu State, Nigeria, including 144 secondary schools, 62 public and 82 private schools (Education Inspectorate Authority, 2024; Post Primary School Management Board, 2024). A representative sample of these schools was selected for inclusion in the study.

Sample and sampling technique

Sampling procedure

The sampling procedure involved multiple stages. Initially, a preliminary survey identified schools familiar with using ChatGPT in mathematics learning. This survey involved contacting public and private secondary schools within the study area and administering questionnaires to school administrators. The responses indicated that only two private secondary schools were familiar with ChatGPT and willing to participate in this research.

School selection

Purposive sampling was employed to select two private secondary schools that were familiar with ChatGPT technology, as identified through a preliminary survey conducted prior to the study. The preliminary survey was essential for gathering initial information on schools' exposure to ChatGPT and determining which schools had prior experience with the technology. This phase allowed for a targeted approach, ensuring that the schools selected for the study had a relevant and informed perspective on the integration of ChatGPT in mathematics education. By using the survey results, we could select schools where participants were more likely to provide insightful and informed data, thereby enhancing the relevance and depth of the study.

Student selection

This study targeted senior secondary school students enrolled in mathematics classes using ChatGPT in the selected schools. A total of 125 students from Class 1, 2, and 3 were invited to participate, with approximately 40 students from each class. These students were permitted to use iPads and laptops for study purposes. Informed consent was obtained from students, as well as their parents and guardians, to ensure voluntary participation and ethical adherence.

Sample size

This study included two private secondary schools (School A and School B) within the Nsukka Education Zone, with a total of 125 senior Class 1, 2, and 3 students enrolled in mathematics classes where ChatGPT was being utilised. Of these, 60 students were from School A and 65 students were from School B. These students met the inclusion criteria, which required them to be enrolled in mathematics classes using ChatGPT and to have permission to use iPads or laptops for study purposes.

Instruments for data collection

This study utilised two primary instruments for data collection: the mathematics students' ChatGPT scale, and a semi-structured interview guide.

Mathematics students' ChatGPT scale (MSCS)

The MSCS was adapted from the 8-item ChatGPT usage scale developed by Abbas et al. (2024) and supplemented with relevant elements from Nguyen's (2024) online survey. Abbas' original scale, which employed a 6-point Likert scale (1 = never, 6 = always), demonstrated strong reliability and validity, with a Cronbach's alpha of 0.914, composite reliability of 0.928, and an average variance extracted of 0.618, exceeding standard reliability and validity thresholds. Nguyen's online survey, created on Google Forms, aimed to investigate English teachers' knowledge and perceptions of ChatGPT, including its usefulness and challenges. The questionnaire included three parts: a consent form, background information (e.g. teaching experience, major/non-major status, prior ChatGPT experience), and questions exploring perceptions of ChatGPT in teaching and assessment practices.

The adapted MSCS was developed to assess students' perceptions of ChatGPT in mathematics learning. It consisted of two sections: Section A gathered demographic data (grade level, gender, age, and location). Section B contained statements measuring students' perceptions of ChatGPT, rated on a five-point Likert scale (strongly agree to strongly disagree). Examples of these items include:

ChatGPT consistently enhances my understanding of complex mathematical concepts.

I rely on ChatGPT as a valuable resource for assistance in mathematics problem solving.

Prior to deployment, the MSCS underwent face validation by three experts in mathematics education and measurement and evaluation. A pilot study was conducted with 45 mathematics students from both public and private secondary schools in a separate education zone. Reliability testing using Cronbach's alpha yielded a coefficient of 0.78, indicating satisfactory internal consistency. The finalised MSCS was administered to students, achieving a 100% retrieval rate, ensuring complete data collection.

Semi-structured interview guide

To gain deeper insights into students' experiences with ChatGPT in mathematics learning, semi-structured interviews were conducted. The interview guide was developed based on a literature review and theoretical framework. Initially comprising 12 open-ended questions, the guide was refined by validation experts, reducing it to four overarching themes aligned with the study's research questions. A pilot study involving five participants was conducted to ensure clarity and effectiveness. Based on the feedback, minor modifications were made to question wording and sequence. To establish reliability, inter-rater reliability was assessed by having two independent researchers conduct interviews with the same subset of participants. The resulting inter-rater reliability coefficient of 0.85 confirmed the guide's consistency and reliability. Through this rigorous validation and refinement process, both the MSCS and the interview guide were confirmed as reliable and effective tools for data collection.

Method of data analysis

Quantitative data from the questionnaire survey were analysed using Special Package for Social Science (SPSS) version 28. Descriptive statistics such as mean (M) and standard deviation (SD) were used to answer the research questions. The average cut-off point utilised from the MSCS was 3.01. Items with a mean of 4.01 or above imply strongly agree (SA), 3.01 to 4.00 indicate agree (A). A response of 3.00 was considered neutral, indicating neither agreement nor disagreement. 2.00 to 2.99 indicate disagree (D), and 1.00 or below imply strongly disagree (SD).

Qualitative data from the semi-structured interviews were analysed thematically following the principles outlined by Braun and Clarke (2006). Thematic analysis was employed to identify patterns, themes, and insights related to students' experiences with ChatGPT in mathematics learning. The researchers followed an inductive coding process involving familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing a final report.

To ensure trustworthiness and validity, several measures were undertaken. Data triangulation was applied by comparing findings from both quantitative and qualitative data sources, ensuring consistency across different methods. The reliability of qualitative analysis was enhanced through inter-coder agreement, where two independent researchers coded a subset of transcripts and compared their results. Member checking was also conducted by sharing summaries of key findings with selected participants to confirm accuracy and credibility.

These approaches strengthened the validity and reliability of the research findings, providing a robust foundation for interpretation and conclusions.

Results

The findings and analysis of the data are presented in Table 1 in accordance with the research questions.

Table 1
Students' perceptions of AI-based ChatGPT in mathematics learning

S/N	Item Statements	Mean	Standard Deviation	Agreement Level
	<i>Usage and Engagement</i>			
1	I consistently use ChatGPT for mathematics learning.	3.22	1.31	A
2	ChatGPT is an effective tool for explaining and reinforcing mathematical concepts.	3.25	1.35	A
3	My engagement with ChatGPT during mathematics learning is frequent.	2.34	1.44	D
4	ChatGPT plays a significant role in my overall mathematics learning experience.	3.43	1.71	A
5	I rely on ChatGPT as a valuable resource for assistance in mathematics problem solving.	2.94	1.13	D
	Grand Mean	3.04		Agree
	<i>Perceptions of Effectiveness</i>			
6	ChatGPT consistently enhances my understanding of complex mathematical concepts.	4.10	.91	SA
7	The guidance provided by ChatGPT has significantly improved my problem-solving skills in mathematics.	4.03	.92	SA
8	Instant feedback from ChatGPT is an invaluable aspect of my mathematics learning experience.	3.36	1.19	A
9	ChatGPT consistently reinforces key mathematical concepts for me.	2.60	1.34	D
10	Overall, ChatGPT is an effective tool for supporting my mathematics learning.	3.17	1.65	A
	Grand Mean	3.45		Agree

S/N	Item Statements	Mean	Standard Deviation	Agreement Level
	<i>Challenges and Reservations</i>			
11	I have encountered inaccuracies or misleading solutions while using ChatGPT for mathematics learning.	2.90	1.62	D
12	I believe that ChatGPT might impede the development of my independent problem-solving skills in mathematics.	3.78	.86	A
13	I feel confident in the accuracy of solutions provided by ChatGPT in my mathematics learning.	4.10	.91	SA
14	The potential overreliance on ChatGPT concerns me when developing my independent thinking skills.	4.03	.92	SA
15	I worry about the reliability of information generated by ChatGPT for my mathematics education.	3.19	1.29	A
	Grand Mean	3.60		Agree
	<i>Preferences and Suggestions</i>			
16	I prefer ChatGPT to adapt its responses based on my learning style.	2.59	1.35	D
17	ChatGPT's ability to tailor responses to my unique learning preferences is important.	3.01	1.53	A
18	I would appreciate more customisation options in ChatGPT that align with my learning needs.	2.42	1.40	D
19	The role of ChatGPT in my mathematics learning aligns well with my preferred learning methods.	3.80	.88	A
20	I value integrating ChatGPT as a complementary tool in my mathematics education.	4.08	.90	SA
	Grand Mean	3.18		Agree

Findings for Research Question 1

Quantitative analysis

Data from Table 1 indicate a mixed perspective among students. On one hand, students generally agreed that ChatGPT plays a significant role in their overall mathematics learning, as evidenced by a mean score of 3.43 (SD = 1.71). On the other hand, there were reservations

regarding the consistency of their engagement with ChatGPT, with a mean score of 2.34 (SD = 1.44) suggesting some disagreement on this point. The overall Grand Mean of 3.04 (SD = 1.29) reflects an aggregate view—indicating that, despite some inconsistencies in engagement, students maintained a generally positive perception of ChatGPT's role in their mathematics education.

Qualitative analysis

Semi-structured interviews with senior students from Schools A and B were analysed thematically (Braun & Clarke, 2006), revealing two main themes.

Theme 1: Positive perceptions of ChatGPT's role

Students highlighted several beneficial aspects of ChatGPT, emphasising its role as a supportive tool in their learning process.

My experience with AI-based ChatGPT in mathematics has been quite positive. It serves as a reliable tool whenever I encounter challenging problems. (Student 1, School A)

Using AI-based ChatGPT has revolutionised my approach to mathematics. It's like having a virtual tutor by my side at all times. (Student 2, School A)

Theme 2: Reservations regarding consistency of engagement

Some students expressed concerns about the variability of ChatGPT's effectiveness and the risk of overreliance.

My experience with AI-based ChatGPT in mathematics has been mixed. While it's helpful for basic problems, I've encountered instances where it provides inaccurate or misleading solutions. (Student 4, School B)

ChatGPT supplements my learning process, but I ensure to engage with other resources as well. (Student 3, School A)

Summary

The integrated findings suggest that students recognise the value of ChatGPT as a significant aid in their mathematics learning journey, appreciating its role in providing instant explanations and guidance. However, concerns about inconsistent engagement and occasional inaccuracies indicate that while overall perceptions are positive, there is room for improvement in its consistent application within the learning environment.

Findings for Research Question 2

Quantitative analysis

Data from Table 1 indicate that students viewed ChatGPT as significantly beneficial for navigating their mathematics studies. Under the "Perceptions of Effectiveness" theme, students strongly agreed that ChatGPT enhances their understanding of complex mathematical concepts, as shown by a mean score of 4.10 (SD = 0.91). They also believed that ChatGPT improves their problem-solving skills, reflected in a mean score of 4.03 (SD = 0.92). The overall Grand Mean of 3.45 (SD = 0.97) further underscores a general consensus regarding ChatGPT's efficacy in aiding both understanding and problem solving.

Qualitative analysis

The semi-structured interviews provided deeper insights into the specific aspects of ChatGPT that students find most helpful. Thematic analysis (Braun & Clarke, 2006) of the interview data revealed two major themes.

Theme 1: Enhanced conceptual understanding

Students consistently reported that ChatGPT helps demystify complex mathematical concepts by providing clear, step-by-step explanations. For example, a student from School A stated:

ChatGPT has been incredibly helpful in grasping complex mathematical concepts. When I struggled with calculus derivatives, ChatGPT provided step-by-step explanations that clarified the process, making it feel like having a personal tutor available 24/7.

Another student mentioned that ChatGPT breaks down intricate topics, such as trigonometry identities, by not only offering solutions but also explaining the underlying steps, thereby deepening their understanding.

Theme 2: Improved problem-solving skills

Students also emphasised that ChatGPT significantly contributes to their problem-solving abilities. They appreciated its capacity to generate multiple approaches to solving problems, which they found instrumental in addressing a variety of mathematical challenges. For instance, a student from School A noted:

When tackling geometry problems, ChatGPT's ability to generate multiple approaches has significantly enhanced my problem-solving skills.

Similarly, a respondent from School B explained,

ChatGPT played a pivotal role in improving my problem-solving skills by offering detailed explanations and real-world examples, enabling me to approach complex problems from various angles.

Summary

Both the quantitative data and qualitative themes indicate that students highly valued ChatGPT for its dual role in enhancing their conceptual understanding and strengthening their problem-solving skills. The strong agreement on these benefits, coupled with rich qualitative insights, underscores ChatGPT's significance as an effective aid in navigating the complexities of mathematics studies.

Findings for Research Question 3

Quantitative analysis

The data summarised in Table 1 indicate a nuanced perspective on the incorporation of AI in mathematics education. Under the "Challenges and Reservations" theme, students expressed concerns regarding potential inaccuracies or misleading solutions provided by ChatGPT, as reflected by a mean score of 2.90 (SD = 1.62), which suggests a tendency toward disagreement with its reliability in some cases. Conversely, students agreed that the integration of ChatGPT does not necessarily hinder the development of independent problem-solving skills, with a mean score of 3.78 (SD = 0.86). The overall Grand Mean of 3.60 (SD = 1.02) indicates that, while students had reservations, there was also recognition of the benefits associated with AI integration. These quantitative results suggest that students held a complex view: they were cautious about the accuracy and potential overreliance on ChatGPT, yet they also appreciated its supportive role in their mathematics learning process.

Qualitative analysis

Thematic analysis of the semi-structured interviews (following Braun & Clarke, 2006) revealed two major themes related to the challenges and reservations expressed by students.

Theme 1: Concerns about accuracy and simplification

Students reported that ChatGPT occasionally provides overly simplified or inaccurate responses when dealing with complex mathematical problems. For example, one student from School A explained:

Sometimes ChatGPT provides solutions that are too simplified, making it challenging to understand complex concepts.

Similarly, a student from School B noted:

ChatGPT sometimes struggles with complex mathematical problems, leading to inaccurate or incomplete solutions.

These responses highlight a common concern regarding the reliability of ChatGPT's outputs, particularly for advanced topics.

Theme 2: Reservations about overreliance and its impact on independent learning

Another prevalent theme was the apprehension that excessive reliance on ChatGPT might impede the development of independent problem-solving skills. Several students expressed caution about becoming overly dependent on the tool. One respondent stated:

I worry that relying too much on ChatGPT might hinder my ability to develop problem-solving skills independently.

Despite these reservations, many students also acknowledged that ChatGPT generally provides accurate and reliable assistance when used judiciously, suggesting that while there are challenges, the technology still plays a supportive role.

Summary

The integrated quantitative and qualitative analyses reveal that students exhibited a balanced view of ChatGPT in their mathematics education. While they expressed concerns about inaccuracies and the risk of overreliance, they also recognised the potential benefits of ChatGPT in enhancing their learning. This mixed perspective underscores the need for a balanced approach to AI integration, one that leverages its strengths as a learning aid while mitigating the risks associated with its limitations.

Findings for Research Question 4

Quantitative analysis

Data from Table 1 reveal mixed responses regarding customisation and integration preferences for ChatGPT in mathematics education. Specifically, students showed some disagreement regarding ChatGPT's current ability to adapt its responses to their learning styles (mean = 2.59) and to offer sufficient customisation options (mean = 2.42). However, they did value its potential to tailor responses to their individual needs, with a moderate level of agreement (mean = 3.01), and they agreed that ChatGPT aligns well with their preferred learning methods (mean = 3.80). Notably, there was strong support for integrating ChatGPT as a complementary tool in their studies (mean = 4.08), and the overall Grand Mean of 3.18 suggests a general consensus that while students appreciated the tool, there is room for improvement in its adaptability and customisation.

Qualitative analysis

Thematic analysis of semi-structured interviews (following Braun & Clarke, 2006) uncovered two primary themes.

Theme 1: Customisation and adaptability

Students consistently expressed a desire for ChatGPT to be more responsive to their unique learning styles. They recommended that the tool should offer:

- Tailored explanations: For example, one student from School A noted the need for more detailed, pace-adjusted explanations and additional practice problems related to specific topics.
- Adjustable difficulty and alternative methods: Another respondent suggested that allowing customisation of the difficulty level and providing multiple problem-solving approaches would better accommodate different learning preferences.
- Interactive and multimedia enhancements: Students from School B highlighted the value of interactive tutorials and multimedia resources that could further personalise their learning experience.

Theme 2: Complementary role in learning

Students also viewed ChatGPT as an important supplementary tool rather than a standalone solution. They emphasised:

- Supplemental support: Many students saw ChatGPT as a valuable assistant that complements traditional teaching by offering real-time feedback and additional practice opportunities.
- Enhanced learning pathways: Several participants envisioned the tool integrating adaptive learning paths and personalised study plans, which would foster deeper understanding and improve problem-solving skills.

Summary

The findings indicate that while students recognised the significant potential of ChatGPT in enhancing their mathematics learning—particularly in clarifying complex concepts and supporting problem-solving—they also desired improved customisation options to better match their individual needs. The overall consensus, as reflected in the Grand Mean of 3.18, underscores the importance of implementing AI-based technologies in a way that is responsive to student preferences, thereby maximising their effectiveness as complementary learning tools.

Synthesis of findings

The study reveals that the secondary school students generally viewed the integration of ChatGPT in their mathematics learning positively, yet their perspectives were nuanced. Quantitatively, students agreed that ChatGPT plays a significant role in enhancing their understanding of complex mathematical concepts and improving problem-solving skills, with high mean scores observed for these aspects. However, the data also indicate mixed perceptions regarding consistent engagement with the tool, as reflected in lower mean scores for this dimension. Qualitatively, students described ChatGPT as a valuable, supportive companion that offers step-by-step explanations and multiple approaches to problem solving. They appreciated its ability to clarify challenging topics and provide real-time assistance, which they likened to having a virtual tutor. At the same time, some students expressed

reservations about its occasional inaccuracies and the risk of overreliance, suggesting that these issues might limit its effectiveness if not addressed.

Furthermore, both quantitative and qualitative findings highlight students' preferences for enhanced customisation. While there was some disagreement about ChatGPT's current adaptability to individual learning styles, many students recommended features such as adjustable explanations, interactive tutorials, and personalised feedback to better align the tool with their unique learning needs. In summary, the integrated findings indicate that while ChatGPT was generally perceived as a beneficial complementary tool in mathematics education, its impact could be further enhanced by addressing concerns about consistency and by incorporating more adaptive, personalised features. This balanced perspective underscores the need for a refined, student-centred approach to the integration of AI in educational settings.

Discussion

RQ1: How do secondary school students perceive the integration of ChatGPT in their mathematics learning journey?

Our findings indicate that students generally view ChatGPT as a valuable support tool in mathematics education. Quantitatively, the overall positive perception is reflected in a Grand Mean of 3.04, despite some variability in engagement (with a mean score of 3.43 for its significance and 2.34 for consistent usage). Qualitative insights reinforce this mixed perspective; while many students praised ChatGPT for its instant explanations and assistance, some expressed concerns over its inconsistent engagement and occasional inaccuracies. These results echo earlier studies (Bonsu & Baffour-Koduah, 2023; Elkhodr et al., 2023) which also noted the potential of AI tools to enhance learning while emphasising the need for consistent application.

RQ2: What aspects of ChatGPT do students find most helpful in navigating their mathematics studies?

Students overwhelmingly appreciate ChatGPT's role in deepening their understanding of complex mathematical concepts and in improving problem-solving skills. Quantitatively, high mean scores of 4.10 and 4.03 for conceptual understanding and problem solving, respectively, underscore these benefits. Qualitatively, students likened ChatGPT to a personal tutor, providing detailed, step-by-step explanations and multiple approaches to solving problems. This finding is consistent with Dasari et al. (2023), who highlighted the effectiveness of AI tools in supplementing traditional instruction and fostering robust problem-solving capabilities.

RQ3: What challenges or reservations do students express concerning the incorporation of AI in their mathematics education?

Despite the benefits, students have articulated specific challenges. Quantitative data indicate concerns about potential inaccuracies in ChatGPT's responses (mean = 2.90) and apprehensions about overreliance. The qualitative data reveal that while students value ChatGPT's assistance, they are wary of its limitations, citing instances of oversimplification and misleading outputs. Such concerns, as also reported by Naher et al. (2023), suggest that while ChatGPT can significantly support learning, its integration must be carefully managed to prevent dependency and ensure that students continue to develop independent problem-solving skills.

RQ4: What preferences and suggestions do students have regarding the integration of ChatGPT in their mathematics education?

When it comes to preferences, students provided nuanced feedback. Although some quantitative measures indicated disagreement regarding the current level of customisation (with mean scores of 2.59 and 2.42 for adaptability and customisation options, respectively), there was strong support for ChatGPT's role as a complementary tool (mean = 4.08), and moderate agreement that it can be tailored to individual needs (mean = 3.01) while aligning well with preferred learning methods (mean = 3.80). Qualitatively, students recommended that ChatGPT should offer more personalised features, such as tailored explanations, adjustable difficulty levels, interactive tutorials, and multimedia resources, to better match their learning styles. These suggestions align with recent calls in the literature (Valova et al., 2024; Wardat et al., 2023) for greater customisation in AI-based educational tools.

In summary, our study reveals that secondary school students perceive ChatGPT as a generally beneficial addition to their mathematics learning, particularly for enhancing conceptual understanding and problem solving. However, challenges related to consistency, accuracy, and limited customisation temper these positive views. The integrated findings suggest that while ChatGPT holds significant promise as a complementary tool, its optimal impact will depend on addressing these concerns, particularly by enhancing its adaptability to meet individual learning needs and by ensuring that its use does not undermine independent problem-solving skills.

Conclusion

This study has revealed that the integration of ChatGPT in mathematics education by exploring students' perceptions, experiences, and challenges. The findings reveal a generally positive perception of ChatGPT among students, highlighting its significance in supporting their learning process and enhancing problem-solving skills. However, concerns about accuracy and reliability remain, underscoring the need for cautious implementation and continued refinement of AI-driven tools in the classroom. Despite these challenges, the study underscores the potential of ChatGPT to complement traditional teaching methods and foster collaborative learning environments. By addressing students' preferences for customisation

and adaptability, educators and developers can better tailor AI-driven tools to meet the diverse needs of learners.

The contribution of this study to the literature lies in its exploration of secondary school students' perceptions regarding the integration of AI-based ChatGPT in mathematics education. Existing literature often focuses on the benefits and challenges of AI integration from the perspective of educators or researchers. However, this study provides valuable insights by directly assessing secondary school students' viewpoints, essential for informing educational practices and technology development. By elucidating students' perspectives, the study adds depth to our understanding of how AI technologies influence learning experiences in mathematics classrooms. The study equally contributes to the literature by highlighting students' preferences and concerns regarding AI integration, thus guiding the development of more user-centred educational technologies. Additionally, the methodological approach of combining quantitative analysis with qualitative interviews enhances the credibility and applicability of the findings. Overall, this research fills a gap in the literature by foregrounding the voices of secondary school students in discussions surrounding AI integration in mathematics education.

The findings of this study underscore several key implications for mathematics educators and educational institutions aiming to integrate AI-based technologies, such as ChatGPT, into mathematics education. Firstly, mathematics teachers should leverage ChatGPT's adaptive capabilities to create personalised learning experiences that cater to individual student needs and preferences. Mathematics teachers can effectively enhance engagement and address diverse learning styles by tailoring responses and learning paths. Furthermore, ChatGPT's ability to offer comprehensive explanations and multiple problem-solving strategies presents an opportunity to enhance students' problem-solving skills. Mathematics teachers could encourage students to utilise ChatGPT to explore different approaches and deepen their understanding of mathematical concepts.

However, mathematics teachers could guide students in balancing autonomy and dependence on ChatGPT. While it offers valuable assistance, students should be encouraged to critically evaluate its solutions and apply their reasoning to mathematical problems. Moreover, integrating real-world examples and applications into ChatGPT's responses can contextualise mathematical concepts and enhance relevance for students. This approach can bridge the gap between abstract concepts and real-world applications, making learning more meaningful.

To foster critical thinking skills, mathematics educators could design tasks and activities that encourage students to engage deeply with mathematical problems beyond ChatGPT's capabilities. This will help cultivate students' higher-order thinking skills and prevent overreliance on AI.

To effectively integrate AI-based technologies into mathematics education, continuous professional development is essential for mathematics educators. Institutions could provide ongoing support and resources to empower educators to leverage these tools to enhance teaching and learning outcomes. Finally, mathematics educators should ensure that

discussions on ethical considerations related to ChatGPT's use in mathematics education are integrated into the curriculum and classroom discourse. This includes addressing issues such as data privacy, algorithmic biases, and promoting responsible AI usage to ensure ethical and conscientious integration of AI technology in education.

The study also has several limitations that warrant acknowledgement. Firstly, the sample size was relatively small, comprising students from only two schools, which may limit the generalisability of the findings. Additionally, the study primarily relied on self-reported student data, potentially introducing biases such as social desirability or recall bias. Furthermore, the absence of perspectives from teachers and other stakeholders overlooks crucial insights into integrating AI into education. The study also did not explore potential differences in perceptions based on demographic factors, such as gender or prior experience with AI technologies. Lastly, the study was conducted within a specific cultural and educational context, which may restrict the applicability of the findings to different settings. Future research should address these limitations by including a larger and more diverse sample, incorporating mixed-methods approaches, involving stakeholders, examining demographic differences, and conducting cross-cultural studies to enhance the understanding and implementation of AI in mathematics education.

Based on the findings of this study, several recommendations are made to enhance the integration of AI-based ChatGPT in mathematics education. Firstly, educational institutions should prioritise providing comprehensive training and professional development opportunities for students and mathematics teachers to utilise ChatGPT in the classroom effectively. This training should encompass technical aspects and ethical considerations surrounding AI use. Secondly, developers of AI-based educational tools should focus on improving the adaptability and customisation features of ChatGPT better to suit students' diverse learning needs and preferences. This could include incorporating adaptive learning algorithms, providing personalised feedback, and offering a variety of learning modalities. Thirdly, mathematics teachers should foster a culture of critical inquiry and digital literacy among students to encourage thoughtful engagement with AI technologies. This includes promoting discussions on ethical issues, algorithmic biases, and responsible AI use in mathematics education. Furthermore, policymakers and educational institutions should collaborate to develop guidelines and policies that promote responsible AI use in education while safeguarding students' privacy and ensuring equitable access to AI technologies. Lastly, ongoing collaboration between researchers, educators, developers, and policymakers is essential to drive innovation in AI-based educational technologies and ensure their effective implementation in mathematics education.

References

- Abbas, M., Jam, F. A., & Khan, T. I. (2024). Is it harmful or helpful? Examining the causes and consequences of generative AI usage among university students. *International Journal of Educational Technology in Higher Education*, 21(1).
<https://doi.org/10.1186/s41239-024-00444-7>

- Ajlouni, A. O., Almahaireh, A. S., & Whaba, F. A.-A. (2023). Students' perception of using ChatGPT in counseling and mental health education: The benefits and challenges. *International Journal of Emerging Technologies in Learning (IJET)*, 18(20), 199–218. <https://doi.org/10.3991/ijet.v18i20.42075>
- Asare, B., Arthur, Y. D., & Boateng, F. O. (2023). Exploring the impact of ChatGPT on mathematics performance: The influential role of student interest. *Education Science and Management*, 1(3), 158–168. <https://doi.org/10.56578/esm010304>
- Bonsu, E. M., & Baffour-Koduah, D. (2023). From the consumers' side: Determining students' perception and intention to use ChatGPT in Ghanaian higher education. *Journal of Education, Society & Multiculturalism*, 4(1), 1–29. <https://doi.org/10.2478/jesm-2023-0001>
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), 77–101. <https://doi.org/10.1191/1478088706qp063oa>
- Dasari, D., Hendriyanto, A., Sahara, S., Suryadi, D., Muhamimin, L. H., Chao, T., & Fitriana, L. (2023). ChatGPT in didactical tetrahedron, does it make an exception? A case study in mathematics teaching and learning. *Frontiers in Education*, 8(January), 1–15. <https://doi.org/10.3389/feduc.2023.1295413>
- Dewey, J. (1933). *How we think: A restatement of the relation of reflective thinking to the educative process*. D. C. Heath & Co.
- Education Inspectorate Authority. (2024). *Private school enrolment statistics in Nsukka education zone*. Nsukka Zonal Office.
- Egara, F. O., & Mosimege, M. (2023). Effect of flipped classroom learning approach on mathematics achievement and interest among secondary school students. *Education and Information Technologies*, 29, 8131–8150. <https://doi.org/10.1007/s10639-023-12145-1>
- Egara, F. O., & Mosimege, M. (2024a). Effect of blended learning approach on secondary school learners' mathematics achievement and retention. *Education and Information Technologies*, 29, 19863–19888. <https://doi.org/10.1007/s10639-024-12651-w>
- Egara, F. O., & Mosimege, M. (2024b). Exploring the integration of artificial intelligence-based ChatGPT into mathematics instruction: perceptions, challenges, and implications for educators. *Education Sciences*, 14(7), 742. <https://doi.org/10.3390/educsci14070742>
- Egara, F. O., Eseadi, C., & Nzeadibe, A. C. (2022). Effect of computer simulation on secondary school students' interest in algebra. *Education and Information Technologies*, 27(4), 5457–5469. <https://doi.org/10.1007/s10639-021-10821-8>

- Elkhodr, M., Gide, E., Wu, R., & Darwish, O. (2023). ICT students' perceptions towards ChatGPT: An experimental reflective lab analysis. *STEM Education*, 3(2), 70–88. <https://doi.org/10.3934/steme.2023006>
- Farhi, F., Jeljeli, R., Aburezeq, I., Dweikat, F. F., Al-shami, S. A., & Slamene, R. (2023). Analyzing the students' views, concerns, and perceived ethics about chat GPT usage. *Computers and Education: Artificial Intelligence*, 5(June), 100180. <https://doi.org/10.1016/j.caeari.2023.100180>
- Getenet, S. (2024). Pre-service teachers and ChatGPT in multistrategy problem-solving: Implications for mathematics teaching in primary schools. *International Electronic Journal of Mathematics Education*, 19(1), em0766. <https://doi.org/10.29333/iejme/14141>
- Govender, R. (2023). The impact of artificial intelligence and the future of ChatGPT for mathematics teaching and learning in schools and higher education. *Pythagoras*, 44(1), 1–2. <https://doi.org/10.4102/PYTHAGORAS.V44I1.787>
- Korkmaz Guler, N., Dertli, Z. G., Boran, E., & Yildiz, B. (2024). An artificial intelligence application in mathematics education: Evaluating ChatGPT's academic achievement in a mathematics exam. *Pedagogical Research*, 9(2), em0188. <https://doi.org/10.29333/pr/14145>
- Mosia, M., & Egara, F. O. (2024a). Predictors of student success in mathematics: Hierarchical bayesian approach. *International Journal of Applied Engineering & Technology*, 6(2), 59–72. <https://romanpub.com/resources/Vol%206%20%2C%20No%202%20-%207.pdf>
- Mosia, M., & Egara, F. O. (2024b). Sustaining retentive memory of mathematics concepts in adolescents utilising game-based learning: A case of repeated measures. *International Journal of Learning, Teaching and Educational Research*, 23(7), 413–434. <https://doi.org/10.26803/ijlter.23.7.21>
- Mosimege, M., & Egara, F. (2023a). Impact of e-learning for mathematics learning: Experience of secondary school students. *Proceedings of ICERI2023 Conference* (pp. 8163–8172). <https://doi.org/10.21125/iceri.2023.2089>
- Mosimege, M., & Egara, F. (2023b). Improving secondary school students' achievement in trigonometry using game based learning approach. In *EDULEARN23 Proceedings* (pp. 8556–8565). IATED. <https://doi.org/10.21125/edulearn.2023.0213>
- Naher, J., Maruf, M. H., Bakht, S. T., & Sadaf, S. S. (2023). A survey to understand the experience of ChatGPT usage among engineering university students in Bangladesh. *Technium: Romanian Journal of Applied Sciences and Technology*, 15, 1–8. <https://doi.org/10.47577/technium.v15i.9660>

- Nguyen, T. C. (2024). University teachers' perceptions of using ChatGPT in language teaching and assessment. *Proceedings of the AsiaCALL International Conference*, 4, (pp. 116–128). <https://doi.org/10.54855/paic.2349>
- Okeke, A. M., Egara, F. O., & Mosia, M. (2025). The Van Hiele model's effects on student attitudes and achievement in geometry content of senior secondary mathematics. *International Journal of Pedagogy and Curriculum*, 32(1), 81–105. <https://doi.org/10.18848/2327-7963/CGP/v32i01/81-105>
- Paterno, J. L. (2023). Revolutionizing math education: Harnessing ChatGPT for student success. *International Journal of Advanced Research in Science, Communication and Technology*, 3(1), 807–813. <https://doi.org/10.48175/ijarsct-12375>
- Piaget, J. (1970). *Science of education and the psychology of the child*. Orion Press.
- Pittalwala, I. (2023, January 24). Is ChatGPT a threat to education? *UCRiverside News*. <https://news.ucr.edu/articles/2023/01/24/chatgpt-threat-education>
- Polyportis, A., & Pahos, N. (2024). Understanding students' adoption of the ChatGPT chatbot in higher education: The role of anthropomorphism, trust, design novelty and institutional policy. *Behaviour and Information Technology*, 1–22. <https://doi.org/10.1080/0144929X.2024.2317364>
- Post Primary Schools Management Board. (2024). *School enrolment statistics in Nsukka education zone*. Nsukka Zonal Office.
- Shoufan, A. (2023). Exploring students' perceptions of ChatGPT: Thematic analysis and follow-up survey. *IEEE Access*, 11, 38805–38818. <https://doi.org/10.1109/ACCESS.2023.3268224>
- Singh, H., Tayarani-Najaran, M. H., & Yaqoob, M. (2023). Exploring computer science students' perception of ChatGPT in higher education: A descriptive and correlation study. *Education Sciences*, 13(924), 1–23. <https://doi.org/10.3390/educsci13090924>
- Sun, D., Boudouaia, A., Zhu, C., & Li, Y. (2024). Would ChatGPT-facilitated programming mode impact college students' programming behaviors, performances, and perceptions? An empirical study. *International Journal of Educational Technology in Higher Education*, 21(1), 1–22. <https://doi.org/10.1186/s41239-024-00446-5>
- Valova, I., Mladenova, T., & Kanev, G. (2024). Students' perception of ChatGPT usage in education. *International Journal of Advanced Computer Science and Applications*, 15(1), 466–473. <https://doi.org/10.14569/IJACSA.2024.0150143>
- von Garrel, J. von, & Mayer, J. (2023). Artificial intelligence in studies: Use of ChatGPT and AI-based tools among students in Germany. *Humanities and Social Sciences Communications*, 10(1), 1–9. <https://doi.org/10.1057/s41599-023-02304-7>

- Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.
- Wardat, Y., Tashtoush, M. A., AlAli, R., & Jarrah, A. M. (2023). ChatGPT: A revolutionary tool for teaching and learning mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, 19(7), em2286. <https://doi.org/10.29333/ejmste/13272>
- Yilmaz, H., Maxutov, S., Baitekov, A., & Balta, N. (2023). Student's perception of chat GPT: A technology acceptance model study. *International Educational Review*, 1(1), 57–83. <https://doi.org/10.58693/ier.114>