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The effect of using technology in teaching and learning mathematics on student's mathematics performance: The mediation effect of students' mathematics interest

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ABSTRACT

The current study aimed to determine the impact of using technology in mathematics teaching and learning on the mathematics performance of students as mediated by students' interest in mathematics. Simple random sampling techniques were used to sample 216 students from the three selected SHS in Kumasi, Ghana. A structured questionnaire was used as an instrument for data collection since the study is purely quantitative. Amos (ver. 23) was used to analyze the structural paths of the study. The results from the analysis reveal that the impact of technology on mathematics performance was positive and significant, and the impact of mathematics interest on mathematics performance was positive and significant. Also, the impact of technology on mathematics interest was positive and significant. Finally, the connection between employing technology in mathematics teaching and learning and students' performance in mathematics is somewhat mediated by students' interest in mathematics, and this relationship is statistically significant. The Ghana Education Service and the Ministry of Education were further advised by the study to incorporate technology into mathematics instruction and learning to boost senior high school students' interest and performance in the subject.

Keywords: mathematics interest, mathematics performance, technology

INTRODUCTION

Students' performance in mathematics has become an issue in the last two decades. Students have in mind that mathematics is the most difficult subject in their cause of study. Though mathematics is regarded as the basic foundation for human development (Yeh et al., 2019). In most African countries especially Ghana, the study of mathematics is made compulsory for every student to study at the basic level of education (from primary one to junior high level) and senior high school (SHS) level, because mathematics is seen as an important tool for national development, and it improves individual learning capability (Ampofo, 2019). Due to the contributions of mathematics to the nation, educational researchers in mathematics are trying to figure out the cause of the decline in students' performance in mathematics. A report from the Ministry of Education has shown that there is a decline in the student's performance in core mathematics during West African senior school certificate examination (WASSCE). According to WASSCE results, the percentage of students who failed to get A1-C6 in core mathematics from the year 2917 to 2019 was 57.3% (2017 WASSCE results), 61.67% (2018 WASSCE results), and 34.45% (2019 WASSCE results) (WAEC, 2017, 2018, 2019). From the above result, it is seen that the performance in core mathematics in the year 2018 is better than in 2017, but the performance declined to 34.45% in the year 2019. This analysis shows that the performance of students in core mathematics cannot be predicted dual to the fact that it changes from year to year. According to a recent survey, the percentage of applicants who took the May/June 2021 WASSCE passed with a grade in core mathematics between A1 and C6 (WAEC, 2021). When comparing the percentage level of 2021 to that of 2018, it is seen that students' performance in the year 2021 is not encouraging as that of 2018. Does this imply that a student's level of mathematical competency is impacted by their interest in the topic or by the way their teacher communicates mathematical concepts and theorems to them?

Due to the high level of poor performance rate in mathematics, different researchers have researched the causes of poor performance of students in mathematics. Some studies are based on the students' interest to determine their mathematics performance (Warren et al., 2021). Others say the gender of the students has a significant effect on their mathematical performance (Innabi & Dodeen, 2018), teacher mathematics self-efficacy affects students' mathematics performance (Perera & John, 2020), and parents' interest in mathematics has an effect on their children's interest and performance (Sibomana et al.,

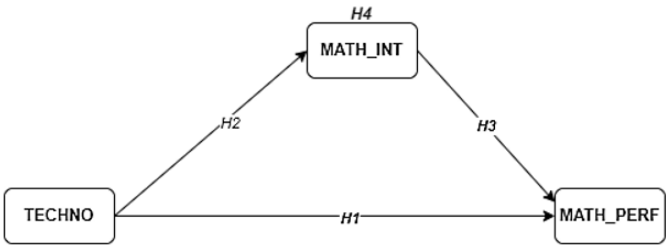

Figure 1. Conceptual framework (Source: Field Survey, 2023)

2021). The educational environment influences students' enthusiasm for learning mathematics positively, according to Vidergor and Ben-Amram (2020). The way the teacher presents the lesson has an impact on the student's motivation in learning mathematics, which will have an impact on their academic achievement, according to Noreen et al. (2019). And also, O'Meara and Prendergast (2019) point out that the time used in teaching mathematics affects students' mathematics performance. The look at the impact of technology as a pedagogy tool could help solve poor performance in mathematics.

Going through the literature, one can see that some previous studies have used interest and attitude toward student's mathematics learning (Yeh et al., 2019), mathematics connections (Arthur et al., 2018), the technology used in mathematics teaching and learning (Lo & Hew, 2021), lack of motivation from teachers and parents, and more to measure students' mathematics performance (Shin et al., 2009). According to Addo (2007), one key factor that attributes to students' performance is the teacher. West African Examination Council (WAEC) (2009) argued that student's poor performance in mathematics is a result of poor knowledge of subject matter, students not fully prepared before the examination, and the poor labeling of diagrams during the examination. The current study deviates from these tendencies by employing student interest in mathematics, as mediated by the technology utilized in mathematics teaching and learning, to measure students' mathematical ability. The current study examines the effect technology in mathematics teaching and learning would spur the interest of students in mathematics and improve their performance in mathematics. Despite the fact that numerous researchers have used technology to assess students' math skills without paying much attention to the impact on mathematics performance. The current study assesses the effect of students' interest in mathematics on mathematical performance, the effect of technology on students' interest in mathematics, and the effect of technology in mathematics teaching and learning on students' interest in mathematics. The study made additional contribution that is to examine students' interest as a mediating effect on the relationship between using technology in mathematics teaching and learning and student's mathematics performance (**Figure 1**).

LITERATURE REVIEW

Technology on Student's Mathematics Performance

The effect of technology on students' mathematics performance is a subject of significant debate and research. While some studies have shown that technology can improve student mathematics performance, other have found no significant difference. One study found that technology-based learning intervention, such as gamification and interactive software, resulted in improved mathematics performance for students' (Hillmayr et al., 2020). Additionally, technology can provide students with immediate feedback on their work, allowing them to self-corrected and adjust more quickly. However, technology is not a panacea for improving mathematics performance (Gómez-García et al., 2020). In some cases, technology can create new challenges for students, such as technical difficulties, distractions, or insufficient training in the use of the technology. Additionally, technology-based interventions may not be suitable for all students and may need to be tailored to individual learning styles and abilities. Furthermore, the effectiveness of technology-based interventions may depend on how the technology is used (Birgin & Acar, 2020). For example, using technology to supplement traditional classroom instruction may be more effective than using it as a replacement for face-to-face instruction (Zengin, 2018). Overall, while technology has the potential to improve students' mathematics performance, the effectiveness of technology-based interventions depends on several factors, including the quality of the technology, the pedagogical approach used, and the individual needs and abilities on the students. Thus, it was suggested that:

H1. The performance of students in mathematics is directly boosted by the use of technology in mathematics teaching and learning.

Technology & Student's Interest in Mathematics

Research suggests that the use of technology in teaching and learning mathematics can have a positive effect on student's mathematics interest (Kelley et al., 2020). Technology can help students to visualize abstract mathematical concepts, make connections between mathematical ideas and actively engage with the material (Rashidov, 2020). This can lead to increase student engagement, interest, and motivation in learning mathematics. For instance, interactive software applications and simulations can provide students with visually rich and interactive learning experiences that can help to make mathematics more interesting and engagement (Cai et al., 2020). Similarly, gamification of mathematics learning, where mathematics concepts are presented in the form of games, can help to make learning more engaging and enjoyable for students. (Sibomana et al., 2021). Using GeoGebra in mathematics teaching and learning will increase students' mathematics interest in curve sketching, probability distribution, 3D graphing, spreadsheet, and CAS (that's integral and derivative of a function), which also has positive effect on

students' mathematics performance (Ponce Campuzano et al., 2018). Gómez-García et al. (2020 found that 64% of their students indicate that they developed much interest in learning mathematics when using technology. This means their level of interest in mathematics arose when they use technology in learning mathematics either in the classroom or outside the classroom. Smaldino et al. (2012) pointed out that using technology in mathematics teaching and learning will not only enhances students' capabilities, but it will improve student's mathematic interest, thus students' will engage more in their learning process. Moreover, the use of technology can provide students with more opportunities for personalized learning, allowing them to work at their own pace and level of understanding (Kang, 2019). Thus, it was suggested that:

H2. Students' interests in mathematics are significantly impacted by the use of technology in mathematics teaching and learning.

Students' Mathematics Interest & Their Mathematics Performance

The performance of students in mathematics is significantly influenced by their interest in the subject (Lerkkanen et al., 2012). When students are interested in a particular subject, they are more likely to pay attention in class, participate actively, and engage in self-study. This can lead to a better understanding of the material, improved problem-solving skills, and higher levels of motivation. Additionally, students who are interested in mathematics are more likely to seek out opportunities for learning and practice outside of the classroom, such as participating in math clubs or competitions, which further enhance their performance (Arthur, 2022). On the other hand, students who lack interest in mathematics may struggle to learning mathematics, leading to lower levels of performance and potentially lower self-esteem (Yeh et al., 2019). Other studies found that student who perform low in mathematics turn to develop less interest in studying mathematics (Barr & Tagg, 1995; Yeh et al., 2019). Students' interest in mathematics is an important factor that predicts their mathematics performance. Singh et al., (2002) also found that the relationship between interest and mathematics performance was insignificant. Thus, it was suggested that:

H3. Student's interest in mathematics has a positive effect on student's mathematics performance.

Mediating Role of Interest

The relationship between the use of technology in teaching and learning mathematics and students' success in math can be explained by the mediating role of the students' interest in mathematics. Technology has become an integral part of teaching and learning mathematics, and it has the potential to enhance students' understanding and engagement with the subject (Thurm & Barzel, 2022). However, the impact of technology on mathematics performance can vary depending on students' interest in the subject (Cullen et al., 2020). Past researchers have suggested a potential influence of technology used in teaching and learning mathematics on mathematics performance (Fabian et al., 2018; Huang et al., 2017). This effect is intervened by students' interests (Safo, 2021). For instants, literature suggested that using technology in mathematics teaching and learning has significant impact on students' mathematics performance (Arhin & Gideon, 2020). Performance in math is also influenced by a student's interest in the subject. This suggests that students' interest in mathematics may play a role in mediating the relationship between employing technology in mathematics teaching and learning and students' mathematical performance. The use of technology in mathematics teaching and learning, as well as students' mathematical performance, depend greatly on their interest in the subject. Thus, it was suggested that:

H4. The association between the use of technology in mathematics instruction and learning and SHS students' mathematical performance is somewhat mediated by students' mathematical interest.

METHODOLOGY

Research Design

The research study samples 300 students from three SHSs in Kumasi, Ghana, using simple random sampling as a sampling technique. 300 datasets were anticipated because the researcher sent each school 100 surveys. The researcher uses three weeks for the data collection. 216 questionnaires were considered to be legitimate for the study's data analysis after three weeks of data gathering. The remaining 84 questionnaires were disregarded because some of them had missing information and others had repeated responses made by respondents to the measuring items.

Sample & Data Collection

The study uses structural questionnaires for data collection. The questionnaire was made of four sections. The first section consists of the background information of the respondents. The second section consist of the five questions under technology in teaching and learning mathematics. The third section also consist of five questions under students' mathematics interest. Finally, the third section consist of five questions under students' mathematics performance. The constructs (questions under the main variables) are measured on a 5-Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, and 5=strongly agree). Age, gender, level of education, and student's course offered are the control variables for the study.

Out of a total of 216 students, 60.2% were males and 39.8% were female. Also, 39.8% were between the age range of 12 to 17 years, 34.7% were between the age range of 18 to 25 years, and 25.5% were above the age of 25. Moreover, of 19.9% were general arts students, 35.6% were science students, 18.1% were agric students, 25.0% were business students, and 1.4% were visual arts students. Finally, 11.6% were Christians, 28.2% were Islamic, 45.8% were traditional believers, and 14.4% were others (**Table 1**).

Table 1. Demographics information of the respondents

Demographics	Number of respondents (n)	Total percentage of respondents (%)
Gender		
Male	130	60.2
Female	86	39.8
Total	216	100
Age		
12-17 years	86	39.8
18-25 years	75	34.7
Above 25 years	55	25.5
Total	216	100
Course		
General arts	43	19.9
Science	77	35.6
Agric	39	18.1
Business	54	25.0
Visual arts	3	1.4
Total	216	100
Religion		
Christianity	25	11.6
Islamic	61	28.2
Traditional	99	45.8
Others	31	14.4
Total	216	100

Table 2. Confirmatory factor analysis

	Standard deviation of factor loading
Technology use in teaching and learning mathematics (TECHNO): CA=.934; CR=.936; & AVE=.787	
T1	∞
T2	.854
T3	.866
T4	.935
T5	.891
Student's mathematics interest (MATH_INT): CA=.921; CR=.927; & AVE=.719	
MI1	.743
MI2	.872
MI3	.895
MI4	.878
MI5	.843
Student's mathematics performance (MATH_PERF): CA=.939; CR=.934; & AVE=.702	
P1	.735
P3	.841
P4	.860
P5	.915
P6	.867
P7	.979

Note. Fitness of the model: CMIN=154.842; df=82; CMIN/df=1.888; CFI=.975; TLI=.968; RMR=.0500; RMSEA=.064; & PCLOSE=.066

Reliability & Validity Analysis

In order to analyze the confirmatory factor analysis (CFA) results, Amos (version 23) was used. CFA outcomes are shown in **Table 2**. According to CFA findings, student mathematics performance had seven measurement items (observed variables), student use of technology in math instruction and learning had five measurement items, and student interest in math had five measurement items. After CFA procedure, every measurement item was still present (**Figure 2**).

To determine the internal consistency, Cronbach's alpha (CA) was used with the retained indicators from explatory factor analysis (EFA). The retained measurement items were utilized to calculate CA using SPSS (version 23). CA must be greater than or equal to 0.7 in order for the reliability score for the observed variables to be acceptable. The latent variables' CA scores were more than .7, indicating that internal consistency had been attained. CA scores for using technology in mathematics teaching and learning, students' mathematics interest, and students' mathematics performance were .934, .921, and .939.

Average variance extracted (AVE) was used to evaluate the observed variables' convergent validity. According to Fornell and Larker (1991), convergent validity for the observed variables was attained if the composite reliability (CR) was at least 0.7 and the least value for AVE was 0.5. According to **Table 2**, the least number for AVE, which represents mathematics performance was.838 while the least value for CR, which represents mathematics performance, was .921. This indicated that the convergent validity of the study had been attained.

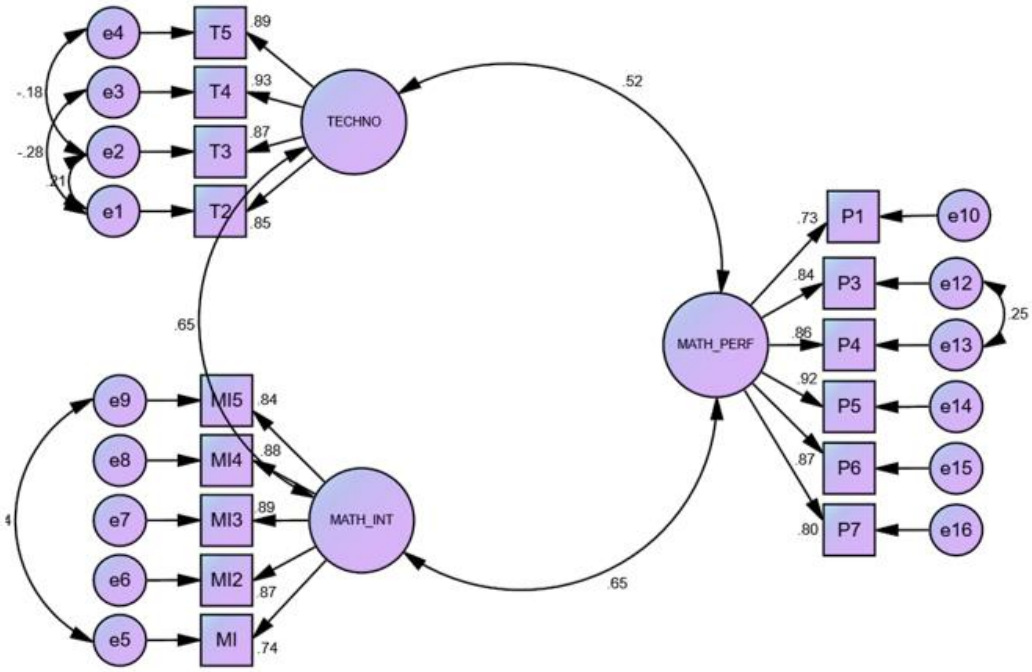

Figure 2. Confirmatory factor analysis (Source: Field Survey, 2023)

Table 3. Discriminant validity analysis

Variables	TECHNO	MATH_INT	MATH_PERF
TECHNO	**0.887**		
MATH_INT	.649***	**0.848**	
MATH_PERF	.524***	.652***	**0.838**

Note. **Bold** & underlined ($\sqrt{\text{AVE}}$); $*_{\sim}$ p − value significant at 5% (0.05); & $**_{\sim}$ p − value significant at 1% (0.01)

Discriminant Validity Analysis

The square root of AVE and the correlation coefficient are compared to determine discriminant validity. When the lowest value of the intercorrelation score is higher than the highest value of AVE score, discriminant validity is attained, claim Sarah et al. (2020). **Table 3** present the analysis results for the discriminant validity. Form **Table 3**, the highest value for AVE was .652, which was statistically significant while the least score for the intercorrelation coefficient was .838. This means that discriminant validity has been achieved for this study.

FINDINGS/RESULTS

The study assessed the mediating effect of students' mathematics interest in the connection between mathematics performance and technology-assisted instruction and learning in mathematics. The analysis of data from SPSS (version 23) and Amos (version 23) is presented in this section.

Table 4 present the direct effect result for the structural path diagram. The analysis output shows that two control variables (age and gender) have a negative effect and statistically insignificant on student's mathematics performance (p-value>.05). Course students peruse has a positive effect and statistically significant on student's mathematics performance (p-value<.01). For the hypothesis from the path diagram, it was found that the impact of technology on mathematics performance was positive and significant (β=.151; CR=2.202). Hypothesis **H1** "Using technology in teaching and learning mathematics had a positive effect on SHS students' mathematics performance", we therefore accept the hypothesis for this study. The impact of technology on mathematics interest was positive and significant with p-value less than 1% (β=.587; CR=8.483). The analysis further explains that technology had 58.7% impact on student's mathematics interest. Therefore, hypothesis **H2** "using technology in teaching and learning mathematics has a direct positive effect on student's mathematics interest", hence hypothesis **H2** is supported. The impact of mathematics interest on mathematics performance was positive and significant with p-value less than 1% (β=.487; CE=5.602). The result explains that as students devote more time to studying mathematics, their performance in mathematics is likely to be improved by 48.7%. Hypothesis **H3** "Mathematics interest has a positive effect on SHS students' mathematics performance" we therefore accept the hypothesis for this study.

Mediating Effect

Amos (version 23) was used to examine the indirect impact of technology use in mathematics teaching and learning on mathematical performance, as shown in **Table 4**. According to **Table 4**, the impact of technology on mathematics performance

Table 4. Direct paths

Direct paths	Standard estimates	Standard errors	Composite reliability	p-value
TECHNO→MATH_PERF	.151	.069	2.202	.028
TECHNO→MATH_INT	.587	.069	8.483	.000
MATH_INT→MATH_PERF	.487	.087	5.602	.000
AGE→MATH_PERF	-.025	.051	-.480	.631
GENDER→MATH_PERF	-.056	.088	-.636	.525
COURSE→MATH_PERF	.135	.038	3.573	.000
Indirect path	**Standard estimates**	**Lower bound (BC)**	**Upper bound (BC)**	**p-value**
TECHNO→MATH_INT→MATH_PERF	.113	.019	.223	.049

Note. ***˷p-value significant at 1%

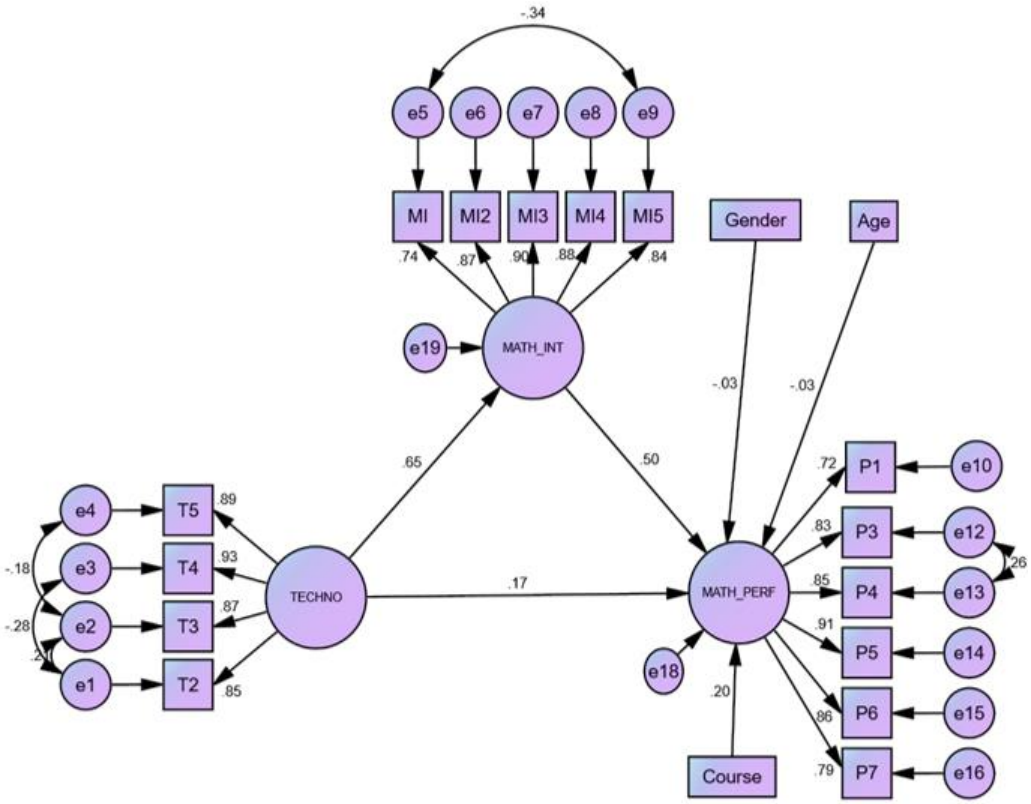

Figure 3. Structure path (Source: Field Survey, 2023)

was positive and significant. In addition to having a favorable and statistically significant impact on student performance in mathematics, mathematics has a positive and statistically significant impact on student interest in the subject. Since the lower bound and upper bound values does not fall within zero. Hypothesis **H4** "student's mathematics interest partially mediates the relationship between using technology in teaching and learning mathematics' and mathematics performance of SHS students", we accept the hypothesis of this study (**Figure 3**).

DISCUSSION

The aim of the study is to determine the impact of using technology in teaching and learning mathematics on student's mathematics performance mediated by student's mathematics performance. Four research hypotheses were tested using 216 respondents.

The first hypothesis examines the direct impact of using technology in teaching and learning mathematics on student's mathematics performance. The analysis results show that technology used in teaching and learning mathematics had a positive influence on students' mathematics performance and it's statistically significant. This results is consistent with previous research that emphasized that using technology in mathematics teaching has a direct positive influence on students' mathematics performance when it is used to assist students in their mathematics classroom given improving their mathematics learning (Ran et al., 2022). When students see the need of using technology in mathematics teaching and learning, it increases their desire to engage in mathematics learning and their mathematics performance. The effect of technology in mathematics teaching and learning on student's mathematics performance has been seen in a variety of educational contexts and age group (Gómez-García et al., 2020). Using technology in teaching and learning mathematics significantly predict student's performance in mathematics (Oppermann et al., 2021). Birgin and Acar (2020) experimented with the use of GeoGebra software to determine 11th-grade

students' mathematics achievement in exponential and logarithmic functions. After the experiment, the result shows that the use of GeoGebra software in teaching mathematics had a significant effect on students' mathematics achievement in exponential and logarithmic functions.

The second research hypothesis also emphasized that the use of technology in mathematics teaching and learning has a positive and statistically significant on student's mathematics interest. The findings align with Wong and Wong (2019) survey the effect of mathematics interest on middle students in a medium-sized metropolitan district. According to their results, higher interest in mathematics learning developed by student's will result in a better mathematics performance of the students. Additionally, several other studies support the findings that the use of technology has a positive effect on student's interest in mathematics. According to Gomes et al. (2020), the poor performance of student's in mathematics is as a results of their lack interest in mathematics learning, which means that mathematics interest serves as a paramount for mathematics performance. Amoako et al. (2022) also insisted that when technology is used for classroom instruction, it firstly has positive effect on student's mathematics perceptions and later have a significant effect on their mathematics interest, which means that the use of technology does not have a direct impact on student's mathematics interest, but it will positively change the perception of students in mathematics learning and in turn result a significant effect on their mathematics interest.

The third research hypothesis also proposed that students' interest in mathematics has a significant effect on their mathematics performance. The finding confirmed with the earlier studies (Eriksson, 2020; Froiland & Davison, 2016; Huang et al., 2020) that student's interest in mathematics positively and statistically significantly predict student's performance in mathematics. The findings propose that students who develop interest in mathematics learning will get a better result in mathematics. The result of the study is in support with other studies, which confirmed that mathematics interest has a significant positive effect on students mathematics performance (Azmidar et al., 2017; Cevik, 2018; Degol et al., 2018; Zhang & Wang, 2020). Students who are interested in mathematics learning contribute a lot in teaching and learning and other activities related to mathematics. Moreover, students who are interested in mathematics are likely to pursue advanced mathematics courses in their tertiary level of education (Eriksson, 2020).

In addition, the mediation analyses also show that the positive relationship between using technology in teaching and learning mathematics and student's mathematics performance was significantly mediated by student's mathematics interest. The present result supports the hypothesized role of student's mathematics interest, which indicates that student's level of interest could have a significant effect on their mathematics performance. Furthermore, the findings of the study are in line with past studies, which reveal student's mathematics interest as a significant predictor of their mathematics performance (Azmidar et al., 2017; Mokhtar et al., 2012). The present results show that using technology in teaching and learning mathematics has a positive effect and statistically significant on student's mathematics performance, using technology in teaching and learning mathematics has a positive effect and statistically significant on student's mathematics interest, and student's mathematics interest has a positive effect and statistically significant on student's mathematics performance. Therefore, the analysis result shows that student's mathematics interest partially mediates the relationship between using technology in teaching and learning mathematics and student's mathematics performance, which means that before technology in mathematics instruction have direct significant effect on student's mathematics performance, with without influencing students' interest in mathematics learning.

CONCLUSIONS

The study concluded that using technology in mathematics teaching and learning has a significant positive impact on student's performance in mathematics. Similarly, students' interest in mathematics has a positive impact on students' mathematics performance and it is statistically significant. The result of the study revealed that student's interest in mathematics partially mediates the relationship between using technology in mathematics teaching and learning and student's mathematics performance.

Recommendations

The report advises Ghana education service to include technology in math instruction and learning to boost SHS students' arithmetic performance. This will be accomplished by instructing teacher candidates on how to utilize math software, such as Microsoft Mathematics, GeoGebra, Math Solver, Maple, and Maxima, in SHS mathematics teaching and learning. It will assist students to develop an interest in studying and solving mathematical problems, which in turn has a substantial impact on their performance in mathematics.

Limitations

First and foremost, the study was purely quantitative, which does not require the respondents to provide additional information apart from the questions presented on the questionnaire. Future study should adopt a qualitative approach, which will permit respondents to express their views on the subject matter.

The study gathered data with the use of questionnaires. The prediction was made with the help of research data using statistical methods.

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Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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