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Impact of Information and Communication Technology (ICT) Facilities on Gender Differentials in Mathematics Performance Among Secondary School Students

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ABSTRACT

The poor performance of students in mathematics indicates that students need to acquire the necessary skills and knowledge required for solving mathematical problems. The study investigated the impact of information and communication technology (ICT) on gender differentials in mathematics performance among secondary school students in Kwara State. The study population consists of all senior secondary school students in Kwara State, Nigeria. The study employed a quasi-experimental design involving the pre-test and post-test non-equivalent control. A sample of 80 students was selected purposively from two secondary schools. The experiment group is involved in mathematics using ICT facilities, while the control group uses the traditional approach. The instrument of the study is a Mathematics Achievement Test (MAT) with a reliability of 0.80, determined using Pearson's product moments correlation statistics. The data generated was analyzed using mean and standard deviation to answer research questions, while the hypotheses tested use ANCOVA at a 0.05 significance level. The result of the study revealed that ICT facilities improved students' achievement and reduced the gender gap in mathematics achievement among secondary school students. Thus, mathematics teachers at the secondary school level should apply information and communication technology (ICT) facilities to teaching mathematics to improve students' performance.

Keywords: information communication technology (ICT), gender differentials, performance, mathematics

INTRODUCTION

Mathematics is essential to every individual's life as it aids the development of knowledge and required skills in problem-solving situations. Mathematics is the bedrock of any nation's scientific and technological development (O'Leary, 2021). Mathematics is one of the few subjects important in the secondary school curriculum due to its relevance to the national interest in economic, scientific, and technological development. Fung (2020) indicated that the study of mathematics was established in schools to produce competent persons who are skillful in applying Mathematical knowledge to solving everyday problems. Mensah et al. (2023) indicated that mathematics is a precursor of scientific discoveries and inventions. It is the foundation for any meaningful scientific endeavor, and any nation developing in science and technology must have a solid mathematical foundation for its youths (Salami and Spangenberg, 2024).

According to Abraham et al. (2022), mathematics is an expounding and evolving body of knowledge and a way of perceiving, formulating, and solving problems in many disciplines. Al-Abdullatif and Alsaeed (2019) indicated that the primary learning goals of students in mathematics are to enable them to become problem-solvers, critical thinkers, team-based workers, logical thinkers, and renowned scientists and technologists with innovative abilities. It becomes worrisome that this subject, with a very high premium, has witnessed a high rate of failure in internal and external examinations. Al-Abdullatif and Alsaeed (2019) noted that despite the vital role of mathematics, it remains one of the subjects in which many students at all levels of the school system persistently perform poorly. Yedilbayev et al. (2023) opined that generally, students fear and hate mathematics, which results in a lack of interest and poor achievement in Mathematics, particularly geometry and mensuration. The poor performance of students in mathematics indicates that students do not acquire the necessary skills and knowledge required for solving mathematical problems (Shé et al., 2023).

LITERATURE REVIEW

Information Communication Technology on Senior School Performance in Mathematics

The pedagogical application of information and communication technologies (ICTs) has become a central focus globally. For the nation to achieve the target of scientific and technological development, there is a dire need to change the method of teaching and learning mathematics from the traditional approach of "talk and chalk" to an ICT-enhanced pedagogical approach. Albeshree et al. (2022) defined information and communication technology as the collection, retrieval, use, and storage of communicating information through computers and microelectronic systems. Billman et al. (2018) viewed ICT as a technology for creating, displaying, storing, manipulating, and exchanging information. Fathurrohman et al. (2021) noted that ICT makes teachers teach mathematics effectively and dynamically as it is more visual, interactive, and stimulating. Students become excited and motivated in the classroom when using ICT instruments; ICT is an excellent instructional medium for gender. The interactive nature of ICT materials allows students to interact, assimilate, collaborate, and take control of the learning process, allowing female students to work independently.

Graham et al. (2021) indicated that if ICT facilities integrated into junior and senior secondary schools are of good quality, and the students have access to and utilize the facilities, there is hope that the attitudes of students would change; there might be improved motivation towards learning school subjects (including mathematics). Christopoulos and Sprangers (2021) stated that using computers as ICT hardware in teaching and learning mathematics enables the students to have an immediate judgment of their problem-solving efficiency as it allows them to have feedback that permits reinforcement. As indicated above, researchers have shown that integrating technologies into classrooms dramatically impacts students' learning and thinking skills. Gender differences in mathematics achievement have continued to prevail in our secondary schools, with male students outperforming their female counterparts. If this situation continues, the much-desired equal opportunity in education will be achieved across genders. Also, the nation's expected scientific and technological breakthroughs will remain a mirage. However, technologies have contributed to enhanced learning and achievement across subjects and levels required for development. Therefore, this study assesses the influence of Information and Communication Technology (ICT) on gender disparity among secondary school students' performance in mathematics.

Empirical Studies on Gender Differences Among Senior Secondary School Students' Performance in Mathematics

The poor performance of students in Mathematics is worsened based on gender, as male students are noted to perform better in mathematics than their female counterparts. Gender-related differences in mathematics performance appeared early and increased with age (Saal et al., 2020). Garrett et al. (2020) explain that when students reach high school, boys often score higher on achievement tests that entail problem-solving in Mathematics than girls. Chiu (2022), in a study, discovered that male students performed better in solving quadratic equations with the completion of the squares method. Belbase et al. (2022) studied gender differences in mathematics achievement, and the result favored males in achievement, interest, and placement in advanced mathematics courses. Lumagbas et al. (2019) agree that gender differences increase at the secondary school level, particularly in situations that require complex reasoning. These are some indications of gender differentials in mathematics performance that tilt in male students' favor.

Genlott and Grönlund, 2016 reviews that there is a need to develop effective methods for implementing key factors for learning making best possible use of ICT innovations in today's information society. The method presented and assessed in the present study, Write to Learn (WTL), is based on a model for combining social and formative interaction between younger peers and teachers with innovative use of ICT for increasing the effects of those learning factors. There is also a gender gap in education. According to the OECD report, "Closing the Gender Gap Act Now" (OECD, 2012), boys in OECD countries lag behind girls in reading skills and are less likely to spend time reading for pleasure, but perform better in mathematics, even though that gap is narrower than the one in literacy (Genlott and Grönlund, 2016).

Barkatsas et. al. (2009) reviewed that boys maintained higher intrinsic value for mathematics and higher mathematics-related self-perceptions than girls throughout adolescence. Need to understand how it is that boys come to be more interested and like mathematics more than girls; and also, why girls perceive themselves as having less talent, even when they perform similarly.

The authors also cited a finding from the program of international student assessment (PISA) 2003 study relating to female students' confidence in mathematics: "females appear to be less engaged, more anxious and less confident in mathematics than males. It is our contention, however, that computer (and technology) confidence is a very different construct to that of mathematical confidence. Mathematical confidence is an affective dimension closely associated with mathematics achievement.

THEORETICAL FRAMEWORK FOR THE STUDY

Information communication technology involves the theories of cognitive development and behavioral learning (Morgan et al., 2019). Cognitive development is an outcome of the use of ICT in teaching mathematics. Behavioral learning theory suggests that students will commit to team efforts if rewarded for that participation and are likely not to commit if no rewards are evident (Morgan et al., 2019). Therefore, both individual and team rewards should be evident when using ICT. Two major theoretical perspectives are related to using ICT in teaching – cognitive and motivational. The cognitive theories emphasize the effects on learners, while the motivational theories emphasize the students' incentives to do academic work. Motivational theories related to ICT learning focus on reward and goal structures (Slavin et al., 2021).

Researchers have raised issues as regards gender in mathematics achievement; for instance (Lumagbas et al., 2019) identified critical beliefs about the usefulness of and confidence in learning mathematics, with males providing evidence that they were more confident about learning mathematics and believed that mathematics was, and would be, more beneficial to them than did females. Male students have more interest in mathematics than females. Chen et al. (2023) indicated that lack of interest in mathematics is among the real problems girls in the developing world face. Lamptey et al. (2021) indicated that girls' lack of confidence in themselves as mathematics learners, their perception of mathematics as complex, and their view that mathematics is a male activity all impacted girls' attitudes, achievement, and participation in advanced courses.

Zambak and Tyminski (2020) found significant differences between student's achievement in mathematics by boys and girls in which boys performed more than girls, boys were more confident in working mathematics than girls, and girls were more convinced that mathematics was a male domain than boys. Owens and Hite (2020) opined that boys are more likely to have mathematical talent than girls while girls are more likely than boys to have verbal talent, leading boys to do better in mathematics than girls, to develop high math ability, self-concepts, and to be more likely to enter math related technical fields. Teachers depend on the conventional approach, which is teacher-centered and allows for student competition. This approach gives room for gender stereotypes, and no active participation is promoted among the students, which in turn places female students at a disadvantage position. Parrella et al. (2022) suggested that mathematics teachers engage students in various learning experiences to promote mathematical exploration and reasoning. These experiences should engage students actively in mathematics, help them discover meaning through manipulations with concrete materials, enable them to learn individually and in groups, and lead them to construct meaning using various resources and instructional materials. In order to improve the student's performance in mathematics, innovative teaching methods change students' notions and negative attitudes about mathematics and thus increase their interest in studying and learning mathematics (Yaw Obeng and Coleman, 2020).

Based on this theory, teachers can structure learning environments that address the variety of learning styles, interests, and abilities found within a classroom. In this strategy, the teachers must sometimes stick to different teaching patterns but rather adapt new ways, such as teaching through audio, video, and field trips. Students have multiple options for taking in information and making sense of ideas (Dolenc and Šorgo, 2020). It allows students to learn at their own pace, in their own way, and be successful (Nicol, 2017). Hence, the present study calls for applying information and communication technology (ICT) facilities in teaching and learning mathematics.

The primary purpose of this study, specifically, was to assess the influence of information and communication technology (ICT) on secondary school students' performance in mathematics to examine the influence of information and communication technology (ICT) on secondary school students' gender disparity in mathematics.

Research Hypotheses

The following hypotheses were formulated and tested in the study.

- There is no significant difference between the mean performance scores of students taught mathematics using information and communication technology (ICT) and those taught without using information communication technology.
- There is no significant difference between the mean performance scores of male and female students taught mathematics using information and communication technology (ICT).

METHODOLOGY

The study adopted the quasi-experimental design involving the pre-test, post-test, and equivalent control design. The population comprises all senior secondary students of government-owned secondary schools in Ifelodun, the local government of Kwara State. A sample of two coeducational secondary schools was selected for the study purposively. In each of the selected schools, two intact classes were randomly selected and assigned to control and experiment groups, respectively, with a total sample of 80 mathematics students from government-owned senior secondary schools from ages 15 to 17 years, with 40 students in the experiment and 40 students in the control groups. The experiment group had 30 females and 10 males, while the control group had 25 females and 15 males. A 30-item objective test called the "Mathematics Achievement Test (MAT)," with questions created by the researcher and drawn with consideration for the subjects taught to the students in algebra, was used to gather the study's data. The researcher provided an example of algebraic expressions, along with guided practice. Variable and verbal expressions were as follows:

a. Examples of algebraic expressions:
   (i) z decreased by 8 is z – 6; and
   (ii) the quotient of 12 and x is 12/x
b. Examples of verbal expressions:
   (i) x/2 is half of x; and
   (ii) 8x is eight times a number, etc.

A table of specifications guided the construction of the instrument by ensuring that the table aligns with curriculum goals and leaning achievement in mathematics, considering the content areas, cognitive levels, revision process and conclusion in creating a valid, reliable and effective mathematics achievement test that meets educational goals. Two mathematics educators and a measurement and evaluation specialist decided on the instrument's face, and content validation, and their professional judgment served as a guide for some of the item reorganization. The test-retest method was administered to 20 students outside the study sample but with the same characteristics to determine the instrument's reliability, which was carried out two times within two weeks, and the data generated was analyzed using Pearson's Product Moment Correlation statistics. The reliability coefficient (r) was 0.80, which was acceptable for the study.

The two groups were pre-tested to determine their cognitive background before the study. After that, research assistants who had spent two weeks, three times a week, receiving one hour a day of training on using ICT resources in mathematics instruction, taught the experiment groups algebra subjects from their syllabus. The experimental group's teaching included projectors, algebra software, computers, and calculators, allowing students to direct their learning process. The researcher monitored the teaching process to ensure the research assistants strictly adhered to the lesson plan. The students had time to manipulate the software, ask questions, collaborate, and formulate and solve problems using the ICT facilities. For example, Introduction to algebraic expressions where students learn about linear equations, such as $y = mx + b$. Also, graphing activity using the graphing tool, students input different equations (e.g., $y = 2x + 3$, $y = -x+1$) to observe how changes in coefficients affect the graph.

The research assistants answered questions and directed the students when required. The control groups were taught by their regular classroom teachers using the traditional "talk and chalk" approach as outlined in the lesson plan, which did not give room for students' participation. The process lasted three weeks, after which a post-test was administered to both groups and scored over 100%. The generated data was analyzed using mean and standard deviation to answer research questions, while the hypotheses were tested at 0.05 level of significance with analysis of covariance (ANCOVA). Achievers in ANCOVA results refer to students whose performance in mathematics significantly improved due to the integration of ICT, as indicated by statistical analyses.

Table 1. Summary of students' performance in experiment and control groups

Group	Test	N	Mean	Standard deviation	Main gain	Difference in mean gain
Experiment	Pre-test	40	11.02	4.71		
	Post-test		13.90	3.71	12.88	
Control	Pre-test	40	10.12	4.43		9.48
	Post-test		13.52	4.99	3.40	

Table 2. Summary of gender achievement in the experimental group

Gender	Test	N	Mean	Standard deviation	Main gain	Difference in mean gain
Male	Pre-test	25	10.65	3.76		
	Post-test		14.95	4.25	14.30	
Female	Pre-test	25	11.23	2.32		2.38
	Post-test		13.15	2.79	11.92	

Table 3. Summary of ANCOVA analysis of students' performance

Source	Type II sum of squares	df	Mean square	F	Significance
Corrected model	670.012	2	833.752	63.689	.000
Intercept	260.021	1	260.021	319.961	.000
Covariate	.072	1	.072	.001	.972
Method	**163.405**	**1**	**163.405**	**84.807**	**.000**
Gender	**.293**	**1**	**.293**	**.005**	**.944**
Achievers	97.947	1	97.947	1.627	.203
Method * gender	.005	1	.005	.001	.993
Method * achievers	.157	1	.157	.003	.959
Gender * achievers	127.498	1	127.496	2.118	.147
Method * gender * achievers	**5.298**	**1**	**5.298**	**.088**	**.767**
Error	13182.667	37	60.195		
Total	444115.000	48			
Corrected total	43852.680	47			

Table 4. The independent t-test of male and female students taught with ICT

Group	t	p	df
Male	3.84	0.005	78
Female	3.76	0.005	78

RESULTS

Research Question 1. What is the difference between the mean performance scores of students taught mathematics using information and communication technology (ICT) facilities and those taught using the traditional approach?

Table 1 shows that the experimental group had a mean gain of 12.88. In contrast, the control group had 3.40, which gave a difference of 9.48 in favor of the experiment group, which implies that those in the experiment group had improved performance in mathematics than those in the control group.

Research Question 2. What is the difference between the mean performance scores of male and female students taught mathematics using information and communication technology (ICT) facilities?

Table 2 shows that male students in the experiment group had a mean gain of 14.30 while their female counterparts had 11.92, with a difference in mean gain of 2.38 in favor of males.

There is a significant difference between the mean performance scores of students taught mathematics using ICT facilities and those taught without ICT.

Table 3 and **Table 4** shows that the model's calculated F-value (84.807) exceeds the table value (3.84). Also, $p < 0.05$ based on the result for the method, the null hypothesis is rejected at a 0.05 level of significance, implying a significant difference between mean achievement scores of students taught mathematics using (ICT) facilities and those taught without ICT.

There is no significant difference between the mean performance scores of male and female students taught mathematics using information and communication technology (i.e., ICT).

Table 3 and **Table 4** shows that the calculated F-value (.005) is less than the table value (3.84) and $p > 0.05$ at a 0.05 level of significance.

DISCUSSIONS

The result of the study revealed that ICT facilities are effective in improving students' achievement in mathematics. Students who were taught mathematics using ICT facilities had higher achievement gains than those taught using the traditional approach. The difference between their mean achievement scores was statistically significant, resulting from the ICT approach's nature as it allowed the students to learn at their own pace, collaborate, solve problems using their preferred procedure, and manipulate the learning facilities. This result agrees with Amador et al. (2021), who discovered that students taught with ICT achieved better than their counterparts taught with conventional lecture methods. Aytekin and Isiksal-Bostan (2019) discovered that using computer-assisted instruction positively affects students' academic achievement. The result of the study also revealed that male and female students taught Mathematics using ICT had improved mean performance scores with a minor difference between them. There was no statistically significant difference between their mean achievement scores.

Finally, the study revealed that students of different levels of achievement and gender had improved achievement in mathematics due to the application of ICT facilities. Thus, there is no gender difference, regardless of whether or not ICT is used. This result is in tandem with Palmer et al. (2018), who discovered that effective instructional strategy reduced the achievement gap between students of different achievement levels.

CONCLUSION AND RECOMMENDATIONS

The result of the study revealed that the application of ICT facilities in teaching mathematics at the secondary school level improved students' performance in mathematics and reduced the achievement gap associated with students' gender and achievement levels. Mathematics teachers at the secondary school level should apply ICT facilities to improve students' mathematics achievement and reduce the gender gap.

The findings imply that teaching through ICT facilities can enhance mathematics achievement. Thus, teachers should be encouraged to use and introduce mathematics concepts with ICT to students at different levels. ICT facilities can create a friendly atmosphere for student-centered teaching and learning to engage students in learning mathematics concepts. By organizing regular training workshops and seminars for mathematics teachers, their knowledge of using ICT facilities in their teaching in the classroom can improve student achievement.

The study was limited to two senior secondary schools in an urban area in Nigeria. The authors suggest similar research in other contexts. Studies comparing urban and rural senior secondary school students' mathematics achievement when taught through ICT facilities are also recommended. The authors further suggest using online ICT facilities in longitudinal studies to follow students' progression in learning mathematics.

Parents may use the outcome of this study to provide educational facilities at home that engage their children in mathematics. Such facilities can provide opportunities for monitoring, advising, and encouraging their children toward positive achievement in mathematics.

The government may also appreciate and use the study's findings to improve and implement the general objectives for mathematics education as drawn up by the Federal Republic of Nigeria (FRN).

Teaching through information and communication technology (ICT) facilities may result in students becoming more focused and willing to dedicate considerable time to engage in mathematics in the classroom. Involving senior secondary school students in information and communication technology (ICT) facilities when teaching mathematics surely yields better mathematics achievement. However, teachers should extend this strategy to also impact students' attitudes positively when learning mathematics.

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