Effectiveness of Technology-Based Classroom Testing on Students' Academic Engagement in Geometry

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Abstract

Purpose: The study aimed to determine the effectiveness of technology-based classroom testing on students' academic engagement in geometry.

Design/Approach/Methods: Four research questions and hypotheses guided the study which adopted the within-subject experimental research design. The Kahoot mobile testing platform was used for the experiment. The study sample consisted of 44 SS II students drawn using a multistage sampling procedure. The instrument for data collection was a Geometry Student Academic Engagement Scale (GSAES) developed by the researcher and face validated by experts. The Cronbach Alpha reliability index of the GSAES was determined to be 0.91. The data for the study was collected on three occasions, before, during and after the experiment. The data was analyzed using Repeated Measures Analysis of Variance.

Findings: The data analysis showed that technology-based classroom testing effectively enhanced students' behavioural, social, cognitive and overall academic engagement in geometry. The difference in students' behavioural, social, cognitive and overall academic engagement in geometry was also significant.

Originality/Value: The study concluded that technology-based classroom testing effectively enhances students' academic engagement in geometry. The researcher recommended, among others, based on the study's findings that teachers should leverage technology-based classroom testing to enhance students' academic engagement.

Keywords: Technology, Testing, Academic, Behavioural, Social, Cognitive, Engagement

Introduction

Students' academic engagement in geometry has been blamed by educational stakeholders for the unsatisfactory performance of students in geometry, a subsection of Mathematics. The West African Examination Council (WAEC) chief examiner's report decry the unsatisfactory situation in mathematics (WAEC, 2023). In the realm of mathematics education, geometry plays a crucial role in developing students' spatial reasoning and problem-solving skills (Eren, et al., 2020). As such, understanding the effectiveness of technology-based testing (TBT) on students' academic engagement in geometry is important. Nwoke (2017) opine that geometry is an important aspect of mathematics, which helps students think logically to understand how to deal with measurements and relationships of lines, space, angles, surfaces, positions, sizes, shapes and solids; to develop spatial abilities in the use of concrete materials and activities, and ideas of construction for fields of architecture and engineering fields. Agbo and Uzor (2021) described geometry as the branch of Mathematics that deals with shapes and space. Geometry in this study is viewed as a branch of mathematics that deals with space, lines, angles and shapes. Perhaps, it can be deduced that the knowledge of algebra offers useful initiatives by which students understand and appreciate the world and space around us. Also, the report suggested that a low level of students' academic engagement is a probable accomplice to the poor achievement of students in geometry-mathematics.

Students' academic engagement has been described as a key factor in raising the level of interest, motivation, and active participation in learning geometric concepts. Engaged students are more likely to persevere through challenging tasks, seek out additional resources for learning, and develop a deeper understanding of the subject matter (Tessmer & Richey, 2017). Abla and Fraumeni (2019) defined academic engagement as the level of intellectual, social and emotional readiness, curiosity and motivation to participate in learning endeavors. To Trowler et al (2022) students' academic engagement is a measure of students' participation in instructionally beneficial activities towards a measurable outcome. According to Agah et al. (2023), students' engagement in learning spaces is a crucial index for academic success. Evans and Zhu (2023) defined students' academic engagement as a measure of students' pursuit of learning objectives with efforts to overcome learning tasks. In this study, students' academic engagement connotes all efforts of student that gravitate towards active involvement with the content of the geometry learning materials to infuse mastery.

Theoretically, the framework of this study rests on the engagement theory, which clones experiences teaching with technology (Kearsley & Shneiderman, 1998). The engagement theory postulates that students connect with learning activities through interaction with others and through meaningful activity tasks. Drawing from the engagement theory, learning is noted to occur when students are sufficiently engaged with peers, significant others, technological devices and the environment. The engagement theory is sufficiently tenable to learning in technology-based environments, which involves collaborative efforts and can facilitate creative, meaningful, and authentic learning to facilitate student participation, interaction, and information access. Technology, including mobile devices, can also facilitate creativity and communication needed to sustain engagement (Bernacki et al., 2020). Students' academic engagement in this study is defined as a function of three component dimensions as accounted in Tomović (2021); and Agah et al. (2023) viz; behavioural engagement, associated with deportments; social or emotional engagement, associated with feelings; and intellectual or cognitive engagement, associated with the intellects.

Existing literature has delineated the dimensions of students' academic engagement. Trowler et al. (2022) defined behavior engagement as the level of students' involvement in learning to comply with behavioral norms, such as regular attendance and participation and eschewing negative or disruptive conducts. Behavioral engagement in this study refers to students' determination to conduct self to achieve the desired personal goals such as developing skills and passing the subject. Such goals can help diminish undesirable behavior by boosting intrinsic motivation and encouraging immersion in the learning process. Sobremisana and Aragon (2016); Delfino (2019); Hollister et al. (2022); He et al. (2022); and Pathak and Mishra

(2023) examined students' behavioural engagement and suggested it as a veritable indictor of academic success, especially when technology is integrated in the learning process. Tomović (2021) defined social engagement as the interaction between students, peers, and instructors that positively contributes to students' overall learning experiences. Social engagement allows students feel emotional, connected and concerned about the content of instruction and others in the learning environment, according to Agah et al. (2023). In this study, social engagement refers to the extent to which mathematics students communicate, feel connected and network with peers, teachers and other significant individuals and resources to surmount geometric problems. Alalwan (2022); Zhao et al. (2022); Pandita and Kiran (2023); and Kumar (2024) examined students' social engagement and highlighted its important contribution to academic success, especially when technology is integrated in the learning process. The intellectual engagement refers to students' cognitive investment and absorption in their academic work, which can stimulate students to go beyond boundaries and enjoy learning challenges (Hsieh & Chen, 2016). In this study, intellectual engagement refers to mathematics students' cognitive investment in the learning content to surmount the technology-based classroom testing (TBCT). Wallace-Spurgin, (2019); Azizan (2023); Godsk and Møller (2024); Ma et al. (2024); and Ma, Mutua and Kigen (2024) examined students' cognitive engagement and highlighted the important role it plays in the academic success of students, especially when technology is integrated in the learning process.

Academic engagements have been found in other fields to be effective in connecting students to real world experiences, thus, making instructional contents meaningful for students. Such a meaningful instruction prepares students for problem solving and enhances students' ability to transfer learning to solve real life problems. Students' academic engagement in geometry will likely position students in the realms of mastery with the learning contents for high achievement and may be indicated by interest, attention, optimism, curiosity and passion to persevere and execute learning tasks. Delfino (2019) highlighted that students' academic engagement is one of the essential ways of understanding the character and attitude of students during instruction. According to Lei et al. (2018), students' engagement is a strong determinant of academic achievement, which is the main focus of all academic interventions, especially in mathematics and specifically in geometry.

Although the importance of geometry in understanding the world around us, a plethora of scholars have been alarmed with the unsatisfactory achievement of students in mathematics over the years that has been tied to such an important part of mathematics. Khansila et al. (2022) believes that a number of reasons suffice why students perform poorly in geometry. Perhaps, among those is the orthodox testing approach used in classrooms, especially in developing countries like Nigeria, which exacerbates the current trend of adopting technology in examinations, according to Oguguo et al. (2024). According to Yilmazer and Keklikci (2015), the use of technology matters tremendously in geometry especially in converting abstract concepts into concrete terms for students. The National Council of Teachers of Mathematics (2000); Agwagah et al. (2019) believe that the use technology to support students' learning in mathematics can be of immense benefits, especially in geometry. Also, this suggests that the abysmal achievement of students in geometry can be alleviated by a technology based classroom testing (TBCT) approach.

The growing concerns of research in recent years, has beamed on exploring the effectiveness of technology-based classroom testing on students' academic engagement and achievement in various academic subjects, including Mathematics. The current wave of technology in education is fast metamorphosing learning spaces (Emaikwu et al., 2015), and is continuously finding enormous usefulness in the practices of assessments (Uduak et al., 2023). Mishra (2024) defined technology based testing (TBT) as a transition from the orthodox pen-and-paper testing to digital testing solutions often referred to as computer-based testing (CBT). In this study, the technology-based tests are assessment approaches that teachers employ to collect evidence of students' learning on geometric content using a test assessable on smart devices. The CBT slightly differs from the TBT in that the former is limited to the use of computer technology while the later expands to the use of other smart devices and internet of things (IoT) to administer, evaluate and report the outcome of test either online or offline unlike the orthodox paper-pencil-based format. Technology-based classroom testing (TBCT) is a formative assessment practice, involving the use of digital tools and platforms to administer tests for assessment purposes in classroom settings (Gikandi et al., 2011), and could be extended to summative as well as authentic assessments if the need arose. Such tests allow for immediate feedback, personalized learning experiences, and opportunities for students to engage with the material in a more interactive manner. Another major advantage of incorporating technology into classroom testing is that educators can better track student progress, identify areas of weakness, and tailor instruction to meet the diverse needs of learners. The emergence defines the modern era of testing which is marked with a sprinting efficiency and flexible.

A growing number of studies have investigated the integration of technology in assessment practices like class tests. Elmahdi et al. (2018) found that technology based formative assessment enhanced students' learning engagement, saved time, guaranteed equal participation opportunities, and made the learning environment fun and exciting. Simpson et al. (2020) demonstrated that technology enhanced formative assessment was effective for enhancing students' engagement and learning motivation. Hagos and Andargie (2022) fount that the integration of technology in formative assessment practices like tests improved students' engagements and learning outcome. Huang et al. (2024) showed that technology-enhanced formative assessment improved students' achievement and engagement in learning. Evidence from these studies suggest technology based classroom tests can influence student engagement by providing immediate feedbacks that facilitate critical thinking, problem-solving abilities, self-esteem, confidence and motivation. However, there is no clear empirical evidence to explain the effectiveness of technology-based classroom testing (TBCT) on students' academic engagement and achievement in geometry. The significance of this study is to provide educators with insights on the effectiveness of technology based classroom testing (TBCT) towards enhancing learning outcomes in geometry. Also, to bridge the gap between technology integration and formative assessment practices in geometry, this study ultimately contributes to the advancement of teaching and learning in mathematics. Hence, the present study investigated the effectiveness of technology-based classroom testing (TBCT) on students' academic engagement for improved achievement in geometry using the Kahoot testing platform. The study was steered by the following questions:

1. What are the mean behavioural academic engagement score of students in geometry before, during and after exposure to TBCT?
2. What are the mean social academic engagement score of students in geometry before, during and after exposure to TBCT?
3. What are the mean cognitive academic engagement score of students in geometry before, during and after exposure to TBCT?
4. What are the mean joint academic engagement (behavioural, social and cognitive) score of students in geometry before, during and after exposure to TBCT?

Hypotheses

HO1: The mean scores of students' behavioural academic engagement in geometry before, during and after TBCT do not significantly differ.

HO2: The mean scores of students' social academic engagement in geometry before, during and after TBCT do not significantly differ.

HO3: The mean scores of students' cognitive academic engagement in geometry before, during and after TBCT do not significantly differ.

HO4: The mean joint academic engagement (behavioural, social and cognitive) scores of students' cognitive academic engagement in geometry before, during and after TBCT do not significantly differ.

Materials and Methods

The within subjects (repeated measure) research design was adopted in the experimental study. According to McLeod (2023) the within subjects research design collects measurements at different times or occasions on the dependent variable condition from the same subjects. The measurement occasions serving as control, one to another (Ugwuany, 2022). The researcher applied the repeated measures research design in the study due to the small sample size accessible due to the availability of mobile smart devices required for the experiment. Three occasions of data were collected in the study, three weeks before the treatment, immediately at the end of the first treatment session (considered as during treatment) and three weeks' time after the treatment (Technology-based classroom testing, TBCT, using Kahoot testing platform). This is represented as:

$$\boldsymbol{O_a} \qquad \boldsymbol{X} \quad \boldsymbol{O_b} \qquad \boldsymbol{O_c}$$

Where,

O_a = before treatment

O_c = after treatment

X = Treatment (TEFA)

O_b = during treatment

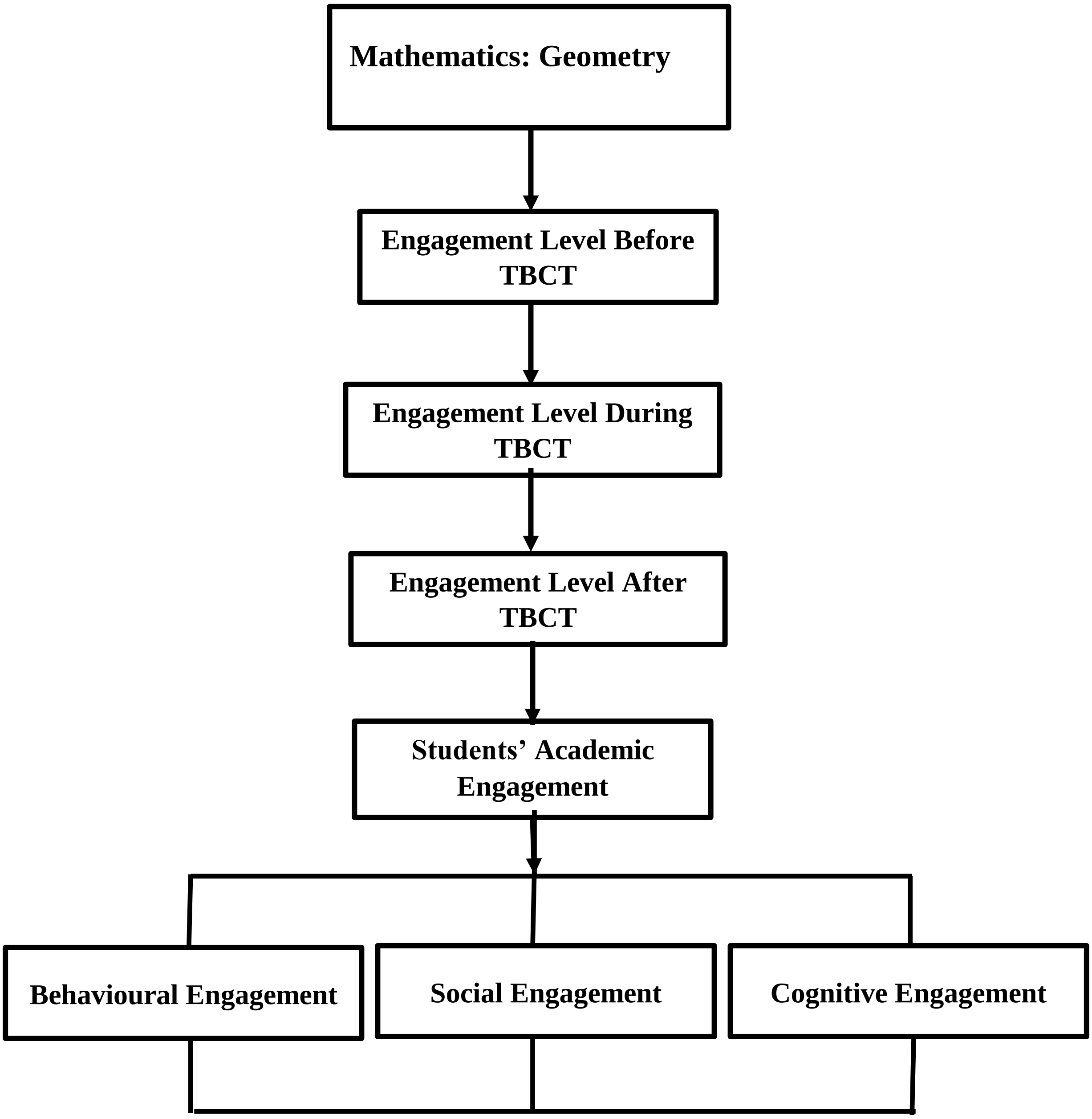

Figure 1. Schematic representation of the study

In Figure 1, geometry is conceptualized as the basis for the problem in mathematics among secondary school students, perhaps due to insufficient engagement with the content of instruction. To investigate the problem, technology based classroom testing (TBCT) was integrated into instruction and data on students' academic engagement level composed of behavioural, social and cognitive engagements were collected from the same set of students before, during and after the TBCT to determine the effectiveness of the instructional intervention at those times separately and collectively as dimensions of students' academic engagement in geometry.

The same subjects participated in all sessions of the experiment. The study was conducted in Nkanu-East Local Government Area (LGA) one of the 17 LGAs and part of the Agbani Education zone, in Enugu State, Nigeria. The sample for the study was 44 SS II (23 male and

21 female) students drawn from a population of 7736 SS II students in the LGA. A multistage sampling procedure was used to draw the sample for the study. In the first stage, two public senior secondary schools in the LGA were drawn by simple random sampling technique via balloting with replacement. In the second stage, a disproportionate random sampling technique was used to draw 22 students from each of the sampled schools. Finally, a simple random sampling technique by a dip-of-luck was used to select the students who participated in the study.

The instrument for data collection was a researcher-developed 27-item "Geometry Student Academic Engagement Scale" (GSAES). The GSEAS was prepared based on the 4-point Likert scale response type and was used to elicit responses on students' academic engagement in geometry. GSEAS contain 9 item statements in each of the three clusters to elicit responses on each domain: behavioural, social and cognitive academic engagement of students in geometry. The GSEAS was face-validated by three experts in the Psychology unit, Department of Educational Foundations, Measurement and Evaluation unit and Mathematics Education Unit, Department of Science Education, all in the Faculty of Education, University of Nigeria, Nsukka. The internal consistency of the GSEAS emerged as 0.91 for the overall scale and 0.93, 0.79 and 0.88 for the respective clusters using the Cronbach Alpha method after pilot testing the instrument on SS II students in Enugu North LGA.

The experiment was conducted directly by two trained regular SS 2 mathematics teachers of the students in the sampled schools as research assistants. The research assistants were trained for three days before the experiment on the purpose of the experiment, the use of the experimental lesson plan, the methods of the experiment and the administration of the instrument. The treatment was a technology-based classroom testing instructional procedure facilitated by the Kahoot platform on mobile phones and the teachers' laptop computer. The data for the study was collected three weeks before the treatment, during the one school week treatment period and three weeks after the treatment. The experiment lasted for seven weeks. Extraneous variables were controlled in the experiment. The single experimental group eschewed any chance of subject interaction. Regular class mathematics teachers were trained and used to conduct the experiment in the sampled schools as research assistants to control for Hawthorne effect. The school administration ensured that the subjects sampled were available and partook in all sessions of the experiment to avoid subject mortality in the experiment. The time lag between the collection of data ensured that the subjects did not simply recall their initial responses on the items and given that they were not informed about the resurgence of the data collection, these minimized the effect of test-wiseness.

The data collected in this study was analyzed by Repeated Measures Analysis of Variance in Statistical Package for Social Sciences (SPSS) version 25 software. Mean and standard deviation were used to address the research questions while the hypotheses were tested at 0.05 level of significance using within subjects Analysis of Variance (ANOVA). The analysis was based on within-subjects effect and the assumptions of data normality and sphericity. The obtained exact probability (p) value was the basis for decision on the null hypothesis, it was rejected if it was less than 0.05. The Mauchly's W test of Sphericity showed a significance of (W=0.97, 2) $p = 0.55$, (W=0.98, 2) $p = 0.62$, (W=0.96, 2) $p = 0.43$ and (W=0.94, 2) $p = 0.30$ for the variables, behavioural engagement, social engagement, cognitive engagement and the joint engagement respectively indicating that the variances of the differences are not significantly different for each, hence implying sphericity in the normally distributed data for the dependent variables in the study.

Ethical Clearance

The management of the sampled school ethics provided ethical permission for the conduct of this study.

Results

Table 1: Mean and standard deviation of students' engagement in geometry n = 44

Test Occasion	Before		During		After	
	$\bar{X}$	SD	$\bar{X}$	SD	$\bar{X}$	SD
Behavioural Engagement	16.14	4.91	21.27	4.95	27.95	3.66
Social Engagement	15.98	3.77	16.52	5.28	19.32	4.22
Cognitive Engagement	19.89	4.83	23.20	4.47	27.05	3.87
Joint Engagement	52.00	9.60	61.00	9.42	74.32	7.49

n = Sample size, $\bar{X}$ = Mean, SD = Standard Deviation

Table 1 presents the mean and standard deviation on the behavioural, social, cognitive and joint dimensions of students' engagement in geometry. Before the treatment, the mean score of 16.14 and a standard deviation of 4.91 was recorded for students' behavioural engagement, during the treatment, a mean score of 21.27 and a standard deviation of 4.95 was recorded for students' behavioural engagement and after the treatment, a mean score of 27.95 and a standard deviation of 3.66 was recorded for students' behavioural engagement in geometry. This indicated that students' behavioural engagement was lowest before the treatment commenced, increased as the treatment progressed and peaked after the treatment was completed with the lowest standard deviation after the administration of the treatment.

From Table 1, prior the treatment, the mean score of 15.98 and a standard deviation of 3.77 was recorded for students' social engagement, during the treatment, a mean score of 16.52 and a standard deviation of 5.28 was recorded for students' social engagement and after the treatment, a mean score of 19.32 and a standard deviation of 4.22 was recorded for students' social engagement in geometry. This also indicated that students' social engagement was lowest before the treatment commenced, increased as the treatment progressed and peaked after the treatment was completed with the lowest standard deviation before the administration of the treatment.

Also, Table 1 shows that prior the treatment, the mean score of 19.89 and a standard deviation of 4.83 was recorded for students' cognitive engagement, during the treatment, a mean score of 23.20 and a standard deviation of 4.47 was recorded for students' cognitive engagement and after the treatment, a mean score of 27.05 and a standard deviation of 3.87 was recorded for students' cognitive engagement in geometry. This also indicated that students' cognitive engagement was lowest before the treatment commenced, increased as the treatment progressed and peaked after the treatment was completed with the lowest standard deviation before the administration of the treatment. While cognitive engagement means increased steadily, the standard deviation reduced steadily indicating a nexus of technology based testing on students' cognitive engagement in geometry.

Furthermore, Table 1 shows that prior the treatment, the mean score of 52.00 and a standard deviation of 9.60 was recorded for students' joint (behavioural, social and cognitive) academic engagement, during the treatment, a mean score of 61.00 and a standard deviation of 9.42 was recorded for students' joint academic engagement and after the treatment, a mean score of 74.32 and a standard deviation of 7.49 was recorded for students' joint academic engagement in geometry. This also indicated that students' joint academic engagement was lowest before the treatment commenced, increased as the treatment progressed and peaked after the treatment was completed with the lowest standard deviation before the administration of the treatment. While joint academic engagement means increased steadily, the standard deviation reduced steadily indicating a nexus between technology based classroom testing on students' joint academic engagement in geometry.

Table 2: Significance in the mean engagement scores of students in geometry due to TBCT

Tests of Within-Subjects Effects

Source	Measure		Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Occasion	Behavioural_ Engagement	Sphericity Assumed	3090.24	2	1545.12	88.80	.00	.67
		Greenhouse-Geisser	3090.24	1.95	1588.21	88.80	.00	.67
		Huynh-Feldt	3090.24	2.00	1545.12	88.80	.00	.67
		Lower-bound	3090.24	1.00	3090.24	88.80	.00	.67
	Social_ Engagement	Sphericity Assumed	282.68	2	141.34	7.39	.00	.15
		Greenhouse-Geisser	282.68	1.96	144.55	7.39	.00	.15
		Huynh-Feldt	282.68	2.00	141.34	7.39	.00	.15
		Lower-bound	282.68	1.00	282.68	7.39	.01	.15
	Cognitive_ Engagement	Sphericity Assumed	1129.56	2	564.78	83.11	.00	.66
		Greenhouse-Geisser	1129.56	1.93	586.90	83.11	.00	.66
		Huynh-Feldt	1129.56	2.00	564.78	83.11	.00	.66
		Lower-bound	1129.56	1.00	1129.56	83.11	.00	.66
	Joint_ Engagement	Sphericity Assumed	11094.97	2	5547.49	107.57	.00	.71
		Greenhouse-Geisser	11094.97	1.90	5856.13	107.57	.00	.71
		Huynh-Feldt	11094.97	1.98	5605.36	107.57	.00	.71
		Lower-bound	11094.97	1.00	11094.97	107.57	.00	.71
Error (Occasion)	Behavioural_ Engagement	Sphericity Assumed	1496.42	86	17.40			
		Greenhouse-Geisser	1496.42	83.67	17.89			
		Huynh-Feldt	1496.42	86.00	17.40			
		Lower-bound	1496.42	43.00	34.80			
	Social_ Engagement	Sphericity Assumed	1643.99	86	19.12			
		Greenhouse-Geisser	1643.99	84.09	19.55			
		Huynh-Feldt	1643.99	86.00	19.12			
		Lower-bound	1643.99	43.00	38.23			
	Cognitive_ Engagement	Sphericity Assumed	584.44	86	6.80			
		Greenhouse-Geisser	584.44	82.76	7.06			
		Huynh-Feldt	584.44	86.00	6.80			
		Lower-bound	584.44	43.00	13.59			
	Joint_ Engagement	Sphericity Assumed	4435.03	86	51.57			
		Greenhouse-Geisser	4435.03	81.47	54.44			
		Huynh-Feldt	4435.03	85.11	52.11			
		Lower-bound	4435.03	43.00	103.14			

Table 2 presents the significance of the means of students' academic engagement on different testing occasions before, during and after exposure to Technology based classroom testing (TBCT). An F value of 88.80 and associated probability value of 0.00 was obtained for the significance of the mean behavioural engagement before, during and after the TBCT treatment. Since 0.00 < 0.05, the null hypothesis one (HO_1**)** which states that the mean scores of students' behavioural academic engagement in geometry before, during and after TBCT do not significantly differ was rejected. Therefore, the mean scores of students' behavioural academic engagement in geometry differs significantly before, during and after TBCT. The effect size of 0.67 indicated that 67% increase in students' behavioural academic engagement scores in geometry was due to the TBCT intervention. This indicates a reasonable difference in the mean behavioural academic engagement scores of students in geometry before, during and after exposure to TBCT.

The obtained F value of 7.39 has an associated probability value of 0.00 for the significance of the mean social engagement before, during and after the TBCT treatment. Since 0.00 < 0.05, the null hypothesis two (HO_2**)** which states that the mean scores of students' social academic engagement in geometry before, during and after TBCT do not significantly differ was rejected. Therefore, the mean scores of students' social academic engagement in geometry differs significantly before, during and after TBCT. The effect size of 0.15 indicated that 15% increase in students' social academic engagement scores in geometry was due to the TBCT intervention. This indicates a reasonable difference in the mean social academic engagement scores of students in geometry before, during and after exposure to TBCT.

Also, the obtained F value of 83.11 has an associated probability value of 0.00 for the significance of the mean cognitive engagement before, during and after the TBCT treatment. Since 0.00 < 0.05, the null hypothesis three (HO_3**)** which states that the mean scores of students' cognitive academic engagement in geometry before, during and after TBCT do not significantly differ was rejected. Therefore, the mean scores of students' cognitive academic engagement in geometry differs significantly before, during and after TBCT. The effect size of 0.66 indicated that 66% increase in students' cognitive academic engagement scores in geometry was due to the TBCT intervention. This indicates a reasonable difference in the mean cognitive academic engagement scores of students in geometry before, during and after exposure to TBCT.

Furthermore, an F value of 107.57 and an associated probability value of 0.00 was obtained for the significance of students' mean joint (behavioural, social and cognitive) academic engagement before, during and after the TBCT treatment. Since 0.00 < 0.05, the null hypothesis three (HO_4**)** which states that the mean scores of students' joint academic engagement in geometry before, during and after TBCT do not significantly differ was rejected. Therefore, the mean scores of students' joint academic engagement in geometry differs significantly before, during and after TBCT. The effect size of 0.71 indicated that 71% increase in students' joint academic engagement scores in geometry was due to the TBCT intervention. This indicates a reasonable difference in the mean joint academic engagement scores of students in geometry before, during and after exposure to TBCT.

Discussion

Findings from the study suggest that technology based classroom testing (TBCT) is effective for improving students' academic engagement in geometry. The finding of the study showed that technology based classroom testing (TBCT) was effective in improving the dimensions of students' academic engagement in geometry. The outcome of the study showed that TBCT improved students' behavioural academic engagement. This may be a result of the ethical conduct often emphasized in computer education lessons encouraging students to comport themselves and behave responsibly instead of conducts that may warrant unsuccessful computer reactions. Also, students in this tech-driven era are often more motivated in when technological devices are applied for instructional purposes. The finding of this study agrees with those of Sobremisana and Aragon (2016); Delfino (2019), Hollister et al. (2022); He et al. (2022); and Pathak and Mishra (2023) to the extent that the integration of technology enhanced students' behavioural engagement. The finding of this study calls to mind the effectiveness of technology based classroom testing in enhancing students' behavioural academic engagement in geometry.

The finding of this study also showed that technology based classroom testing (TBCT) was effective in improving students' social academic engagement. This may be as a result of the need to navigate the computer program environment in the quest for success on the testing which may not be a requirement on the geometry trait being tested. Also, the current adoption of technology encourages a certain degree of collaboration with peers to advance and make the best use of the technology device and platform. The finding of this study agrees with those of Alalwan (2022); Zhao et al. (2022); Pandita and Kiran (2023); and Kumar (2024) to the extent that the integration of technology enhanced students' social engagement. The finding of this study calls to mind the effectiveness of technology based classroom testing in enhancing students' social academic engagement in geometry.

Also, the finding of this study showed that technology based classroom testing (TBCT) was effective in improving students' cognitive academic engagement. This may be because the testing program environment motivates students to perform at their intellectual peak. Also, it may have some potentials to ignite a connection to the real world senecios and support meaningful learning thus enhancing geometry problem solving skills and engaging the cognitive ability of students. In fact, technology based testing in classrooms may have strong capabilities following the immediate feedback to stimulate students mental functioning and the curiosity to sustain their engagement in learning geometry. The finding of this study agrees with those of Wallace-Spurgin, (2019); Azizan (2023); Godsk and Møller (2024); Ma et al. (2024); and Ma et al. (2024) to the extent that the integration of technology enhanced students' cognitive engagement. The finding of this study calls to mind the effectiveness of technology based classroom testing in enhancing students' cognitive academic engagement in geometry.

Furthermore, the finding of this study portrayed the effectiveness of technology based classroom testing (TBCT) in improving students' joint or overall academic engagement based on the behavioural, social and cognitive dimensions. It is possible that the integration of technology in the classroom testing scenarios may have warranted the unprecedented improvement in students' academic engagement mean scores. The current day students, as digital natives are very comfortable with technological tools and when such devices are integrated in the instructional environment, one can only expect a heightened response of students expressed by their engagement in the academic matters for as long as such intervention is sustained. The finding of this study agrees with those of Lei et al. (2018); Delfino (2019); Alalwan (2022); Zhao (2022); Pandita and Kiran (2023); Pathak and Mishra (2023); and Kumar (2024) to the extent that the integration of technology enhanced students' academic engagement. The finding of this study emphasizes the effectiveness of technology based classroom testing in enhancing students' academic engagement in geometry.

Conclusion

The continuous intrusion of technology in classrooms and the attendant interest of students to explore beyond boundaries has raised curiosity concerning the effectiveness of technological interventions in classrooms. The purpose of the study was to determine the effectiveness of technology based classroom testing (TBCT) on students' academic engagements both separately as dimensions of academic engagements (behavioural, social and cognitive) and jointly in geometry. The within subjects, repeated measures research design was adopted for the study. The study found that TBCT was effective for improving students' academic engagement in geometry. Therefore, the study concluded that TBCT effectively enhances students' academic engagement in geometry.

Recommendations

Relying on the outcome of this study, the researchers recommended among others, that:

1. Teachers should leverage technology-based classroom testing to enhance students' academic engagement.
2. School management should support technology-based classroom testing in their schools for enhanced students' achievement.
3. Government should collaborate with experts in providing support, training and facilities for effective implementation of technology-based classroom testing in schools to ensure students engage with geometry lesson contents to foster improved academic achievement in mathematics.

Availability of Data and Material

The dataset generated and analysed during the current study are available in SPSS ".sav" format in google drive repository at https://drive.google.com/file/d/1B1hkcy3yzoTL2Y1vJrnCzMxcXlQZFbjn/view?usp=sharing

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