



Gender Difference in Students Engagement in Technology Supported Inquiry Based Physics Learning (TSIBPL) among Secondary School Students in Kebbi State, Nigeria

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Abstract

Physics education in secondary schools often reflects gender disparities, with female students frequently showing lower levels of participation, confidence, and achievement. This research sets-out to investigate how male and female students engage in technology-supported inquiry based learning in physics using tools like PHET interactive simulations. The study will assess whether technology enhances engagement equally across genders physics in some selected secondary school in Kebbi State. A quasi experimental design on a sample of 120 male and female was used in the conduct of the research. The result indicated a favorable increase in participation and performance of both male and female. The study recommends the gender inclusive STEM teaching strategies and support policy decision on digital learning in Nigeria.

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Keywords: Gender differences, technology-supported inquiry-based learning, physics education, student engagement, secondary school students

Introduction

Physics plays a critical role in scientific and technological advancement. However students' engagement in physics classrooms remains low especially among female students in Nigeria. Traditional lecture-based methods limit participation and hinders conceptual understanding. Inquiry based learning promotes active participation allowing students to explore and construct knowledge. The integration of PhET interactive simulations enhances visualization and experimentation, making abstract physics concepts easier to understand. Despite these innovations gender disparities in engagement persist due to sociocultural factors, access to technology and differences in learning experiences. This study investigates how technology-supported IBL influences engagement among male and female students.

Nigerian Students often struggle with physics due to: lack of conceptual understanding, limited hands-on experimental opportunities, passive learning environments, insufficient integration of technology in teaching (Misra, 2019) ^[15] Research has proven that the appropriate drugs for the above lacks is inquiry based learning although its implementation without technological support may be limited in effectiveness (Misra, 2019 ^[15], Korkman & Metin(2021) ^[11] . Conversely, technology alone without proper pedagogy may not yield meaningful learning. This study seeks to address the gap by examining the combined effect of technology and inquiry-based learning in physics education in Kebbi state Senior Secondary schools. The study will provide empirical evidence on the effectiveness of technology-supported inquiry-based learning

Literature review

This reviews relevant literature on technology-supported inquiry-based learning and its application in the teaching of physics at the secondary schools level. It examines key concepts, theoretical foundations, empirical studies, and gaps in existing research. Inquiry-based Learning (IBL) is referred to as scientific inquiry, which points to an expression of the nature of science or doing the work of scientist it is a student-centered instructional approach that emphasizes active participation in the learning process

through questioning, investigation, and critical thinking (Bako, *et al.* 2022 ^[3], Miller, 2014 ^[13], Minner, 2010 ^[14]). Rather than passively receiving information, students

construct knowledge by engaging in scientific inquiry processes similar to those used by professional scientists. The stages involve in IBL are

Asking questions → formulating hypotheses → conducting investigations → analyzing data
→ drawing conclusions

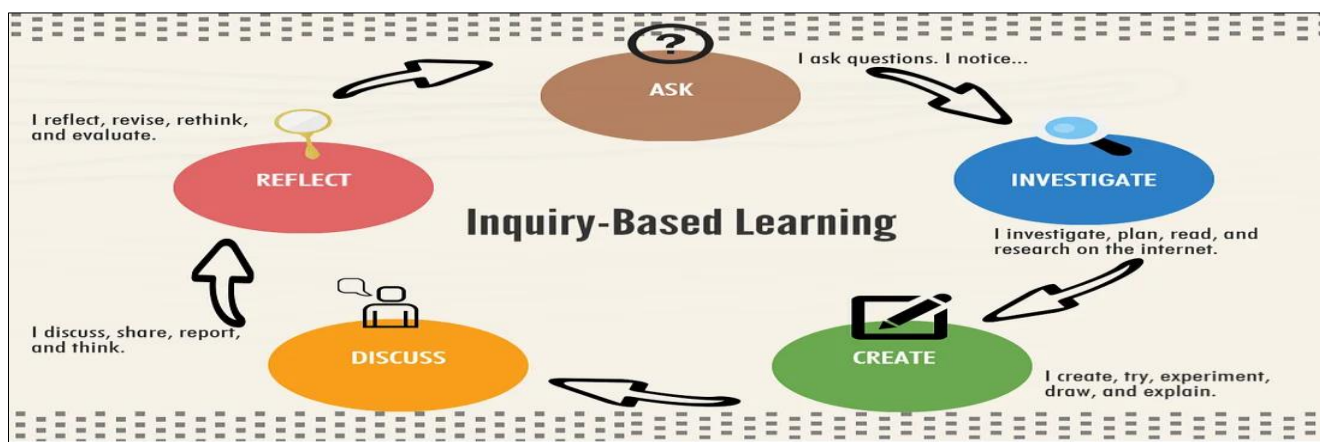


Fig 1

Studies of Şengül and Karabacak (2026) ^[17] found that IBL promotes cognitive, epistemic, and affective development among learners. According to Alachi, *et al.* (2021) ^[1] and Bioco & Echaure (2021) ^[5] inquiry-based instruction in physics laboratories significantly improves students' understanding of the nature of science and experimental reasoning. Bako and Phang (2020) ^[4] found IBL to improve critical thinking capabilities in Physics amongst Nigerian students. The inquiry approach is student-centered learning that emerged from the constructivist paradigm (Demir & Abell, 2010; Gormally *et al.*, 2011 ^[9]). The teacher's role in the constructivist view is to facilitate student efforts, to develop and consolidate their inferences on the subject (Fosnot, 2005 ^[7]; Francis & Mabel, 2016; Gormally *et al.*, 2011 ^[9]; Capps & Crawford, 2013 ^[6]).

Technology-supported learning refers to the integration of digital tools and resources to enhance teaching and learning processes. In physics education, such technologies include: Simulation software (e.g., PhET), Virtual laboratories, Augmented Reality (AR) and Virtual Reality (VR), Artificial Intelligence (AI)-based learning platforms, Data logging and visualization tools (android phones, smart phones. Liang *et al.* (2026) highlight the rapid growth of AI-driven tools in physics education, enabling personalized and adaptive learning experiences. Additionally, Warkentin *et al.* (2025) demonstrated that augmented reality tools improve students' conceptual understanding of complex topics such as electromagnetic forces by providing immersive visualizations.

The combination of technology and inquiry-based learning creates a powerful instructional approach that enhances both engagement and understanding. Technology provides the tools for exploration, while inquiry-based pedagogy provides the structure for meaningful learning. In the study of Benkosi and Ramnarain (2024) emphasizes the importance of combining technology and IBL, they added that the

integration has vast benefits such as enabling learners to grasp and understand concepts better through active involvement in their own learning. In another related study conducted by Sweet and Villaruel (2025) on the use of PhET simulations within inquiry-based frameworks found significant improvements in students' higher-order thinking skills and problem-solving abilities. Similarly, research on technology-assisted inquiry modules shows that students develop better scientific literacy and critical thinking when exposed to this integrated approach. This integration supports visualization of abstract concepts, safe experimentation in virtual environments, immediate feedback and data analysis, as well as, collaborative learning

Our schools are traditionally known to have large class sizes, classified as lecture-dominated instruction, invariably with limited student interaction and emphasis more on mathematical problem-solving. While this approach ensures content coverage, it often fails to promote conceptual understanding. Many students struggle to connect theoretical knowledge with real-world applications. Recent literature suggests that adopting student-centered approaches such as technology-supported IBL can address these challenges. Njofuni *et al.* (2025) ^[16] found that inquiry-based instructional models significantly improve students' performance in physics topics such as optics, particularly in contexts similar to developing countries.

Theoretical Framework

This study is anchored on the following theories constructivist learning theory, Inquiry learning theory, cognitive theory of multimedia learning and technology acceptance model (TAM)

The constructivist learning theory posits that learners actively construct knowledge through interaction with their environment. Learning occurs when individuals engage in meaningful activities and reflect on their experiences (McLeod, 2019) ^[12]. The theory supports inquiry-based learning, as students explore concepts actively, build on prior

knowledge and engage in problem-solving (Korkman and Metin, 2021) ^[11]. Similarly, technology enhances constructivist learning by providing interactive environments where students can experiment and visualize concepts. In the case of Inquiry learning theory, it emphasizes the development of knowledge through questioning and investigation. It aligns closely with scientific methods and promotes curiosity, critical thinking, scientific thinking and Independent learning.

According to Şengül and Karabacak (2026) ^[17] inquiry-based approaches foster deeper engagement and understanding when properly guided. On the other hand cognitive theory of multimedia learning proposed by Mayer, suggests that learning is more effective when information is presented using both visual and verbal formats. Technology tools such as simulations and animations are found to reduce cognitive load, enhance understanding of abstract concepts and improve retention. Finally, technology acceptance model (TAM) explains how users adopt and use technology based on perceived usefulness and perceived ease of use (Unlusoy,2006) ^[18]. In the context of this study, students' acceptance of technology influences the effectiveness of technology-supported inquiry-based learning.

Research objectives

To determine the engagement levels of male and female students in Technology Supported Inquiry Based Physics Learning

To compare engagement dimensions (behavioural, emotional, cognitive)

To examine the effect of technology-supported IBL on students achievement in Physics

To investigate whether gender influence engagement when technology is used access students achievement in physics

To identify challenges affecting student's engagement in technology based IBL

Research questions

- What is the level of student's engagement in technology supported IBL?
- Is there a difference between male and female students' engagement in technology-supported IBL?

Data Presentation/analysis

Table 1: Pre-test result of male and female in technology supported inquiry-based physics learning

Gender	N	Mean	Standard Dev.	Mean diff	T	df	p
Male	70	29.56	6.75	7.46	5.73	118	<.001
Female	50	22.10	7.26				

Table 1, shows that the male students obtained a higher mean pre-test score $M = 29.56$, $SD = 6.75$ than female students

- How does technology-supported IBL influence student interest in physics?

What factors contribute to gender difference in engagement?

Research hypothesis

H0: There is no significant difference between male and female students' engagement in technology supported IBP among kebbi state secondary school students

H1: There is significant difference between male and female students' engagement in technology supported IBP among kebbi state secondary School students

Methodology

This research work used the quasi research design on senior secondary school (SSS2) Physics students in Kebbi State. The entire kebbi state secondary school students comprised the population of this research in which a sample of 120 male and female students were selected based on their questionnaire response. A physics engagement questionnaire (PEQ) was served to the students to account for their willingness to participate in the study. All the returned questionnaires were screened, many were returned uncompleted, very few questions were answered, the researcher decided to accept only 50% answered questions to be included in the research study. A Physics Achievement Test (PAT) was used on the sample of the study,

Validity and Reliability

The questionnaire and the test instruments were faced validated by experts in physics and the department of measurement and evaluation while the reliability the instruments were determined to be 0.72 using Cronbach alpha.

Procedure

The students sampled were grouped into control and experimental groups. The PAT was administered to all of them. Six (6) weeks training on IBL and technology [simulation, guided inquiry, problem solving tasks and observation was given to the experimental group then post-tested.

$M = 22.10$, $SD = 7.20$, the independent sample t-test t_{cal} (118= 5.73. At $\alpha = 0.05$, $t_{crit} = \pm 1.98$

Table 2: the post test result of male and female in technology supported inquiry-based physics learning

Gender	N	Mean	Standard Dev.	Mean diff	t	df	p
Male	70	54.51	6.69	0.75	0.66	118	<.510
Female	50	53.76	5.66				

Table 2, shows that the male students obtained mean post-test score $M=54.51$, $SD= 6.69$ and the female students $M=53.76$, $SD= 5.66$, the independent sample t-test t_{cal} (118= 0.66. At $\alpha = 0.05$, $t_{crit} = 0.51$

Analysis/Interpretation

Table 1 indicated that the male students obtained a higher mean pre-test score $M= 29.56$, $SD= 6.75$ than female students $M=22.10$, $SD= 7.20$, and that the independent sample t-test t_{cal} (118= 5.73. At $\alpha = 0.05$, $t_{crit} = \pm 1.98$ revealed that this difference was statistically significant $t(118) = 5.73$. $P < 0.05$. An independent samples t-test was conducted to determine whether a significant difference existed between

male and female student's pre-test scores technology supported inquiry-based learning of physics results showed that male students scored significantly higher than the female students at (118) =5.73. $P < .001$. Thus, the null hypothesis was rejected.

Table 2 revealed that the male students obtained a slightly higher mean score than the female students. The difference is not statistically significant since the $t(118) = 0.66$ while $p= 0.510$. In conclusion the null hypothesis is retained that is there is no significant difference between male and female students' engagement in technology supported IBP among kebbi state secondary school students

Table 3: summary of Gender difference in pre-test and post-test scores

Test	Gender	N	Mean	SD	t	df	P	Decision
Pre-test	Male	70	29.56	6.75	5.73	118	<.001	Reject H_0
	Female	50	22.10	7.26				
Mean diff.			7.46					
Post-test	Male	70	54.51	6.69	0.66	118	0.510	Accept H_0
	Female	50	53.76	5.66				
Mean diff.			0.75					

Table3 presents a summary of the pre-test and the post-test results of the kebbi state secondary school engagement in technology supported inquiry physics learning. The null hypothesis in the pre-test was rejected while the null hypothesis was accepted after the treatment

Results and discussion

The outcome of the result indicates an improvement in the students' academic performance after exposure to technology-supported inquiry-based physics learning. Their post-test means score suggest that the instructional approach enhanced students understanding of physics concepts. This finding may be attributed to the learner-centred nature of the IBL where students actively investigate explore and construct own knowledge. The study corroborates with the study of Unlusoy (2006) ^[18]; Yeboah, *et al*, (2020) ^[19]; Kori, (2021) ^[10]; Alachi, *et al*, (2021) ^[1]. The integration of technology likely provided visualization, simulation and immediate feedback, thereby, improving conceptual understanding. The result of the finding also revealed that male and female students benefited similarly from the technology-supported IBL. Although slight difference in mean score existed the difference were not statistically significant. This suggest that technology supported inquiry-based physics learning environment where both male and female students have equal opportunities to participate, investigate and developed scientific understanding

The findings also informed the increased in active participation, collaboration and problem-solving among students. The use of digital tools simulations, videos and interactive activities may have increased students' motivation and interest in physics. This support the argument that modern instructional methods can make physics more meaningful and less abstract.

Educational implication

The paper identifies the following implications in the educational sector

- Physics teacher should move away from exclusive reliance on lecture methods
- Technology can serve as an effective instructional tool in secondary school physics.

- Inquiry activities can reduce gender disparities in science classrooms.
- Curriculum planners should incorporate inquiry based and technology supported activities into physics instruction
- Teacher training programmes should emphasize inquiry pedagogy and educational technology.

Suggestions

The following are some suggested extracts based on the findings the study

- Physics teachers should adopt technology supported inquiry strategies during classroom instruction
- Schools should provide adequate technological facilities for science teaching
- Students should be encouraged to actively participate in investigations and collaborative learning activities
- Professional development programmes should be organized for teaches on inquiry based instructional methods
- Parents and school administrations should support the use of educational technologies in science learning.

Recommendations

The paper recommends that for each component of a school system i.e. the teachers, school administrators, government and researchers should;

- Employ the technology supported inquiry regularly,
- they should encourage equal participation of male and female students
- they should use simulations, videos and digital resources to explain concepts
- The school administrators should provide internet facilities, computer projectors and other instructional technologies.
- they should support teachers through training opportunities
- The government should invest in technological infrastructure in secondary schools.
- organize workshops on IBL science teaching

- review science curricular to accommodate technology supported inquiry activities
- researchers should conduct similar studies in other states and educational level
- they should investigate other variables such as attitude motivation and retention
- they should examine the long-term effect of TSIBL on student's achievement

Conclusion

The study concluded that TSIBL in physics learning is an effective instructional approach for improving student's achievement in physics. The approach promotes active learning and provides equitable learning opportunities for both male and female students. Consequently, its adoption in secondary school physics classrooms is strongly recommended.

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