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The Impact of Inquiry-Based Learning on Student Engagement in Ugandan Secondary School Science Classrooms.

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Abstract: Background: *Science education in Ugandan secondary schools has been characterized by traditional teacher-centered pedagogical approaches that result in low student engagement and passive learning. Inquiry-Based Learning (IBL) has emerged internationally as a promising approach to enhance engagement, yet empirical evidence of its impact within the Ugandan context remains limited.* ***Objective:*** *This study investigated the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms, examining behavioral, emotional, and cognitive dimensions of engagement while identifying implementation challenges and enabling factors.* ***Methods:*** *A mixed-methods quasi-experimental design was employed across six purposively selected secondary schools in Central Uganda, with 420 Senior Two students (210 intervention, 210 control) participating over one academic term. The intervention group received IBL instruction while the control group continued with traditional methods. Quantitative data were collected using a validated Student Engagement in Science Classrooms Scale administered at pre-test and post-test, supplemented by structured classroom observations. Qualitative data were gathered through semi-structured interviews with 18 teachers and four focus group discussions with 32 students. Sample size was determined through power analysis to detect medium effect sizes with 80% power. Statistical analyses included independent and paired samples t-tests, ANCOVA controlling for baseline differences, MANOVA for multivariate effects, and linear mixed-effects models accounting for nested data structure. Qualitative data were analyzed thematically using NVivo software, with findings triangulated with quantitative results.* ***Results:*** *Baseline comparisons confirmed no significant differences between groups. Post-intervention, the intervention group demonstrated significantly higher engagement across all dimensions compared to controls (behavioral: $d = 1.39$, emotional: $d = 1.28$, cognitive: $d = 1.26$, overall: $d = 1.48$; all $p < 0.001$). ANCOVA revealed adjusted mean differences of 0.85-0.88 points on the 5-point scale, with MANOVA confirming multivariate effects (Wilks' Lambda = 0.548, $p < 0.001$, partial $\eta^2 = 0.452$).* ***Conclusion:*** *Inquiry-Based Learning had a substantial positive impact on student engagement in Ugandan secondary school science classrooms across behavioral, emotional, and cognitive dimensions. The large effect sizes and consistency across analytical approaches provided robust evidence that IBL successfully transformed passive learners into active, enthusiastic, and cognitively invested students.*

Keywords: Inquiry-Based Learning and student engagement

Introduction of the Study

Science education plays a crucial role in preparing students for the challenges of the 21st century, fostering critical thinking, problem-solving skills, and scientific literacy. However, in many Ugandan secondary schools, science classrooms continue to rely heavily on traditional teacher-centered pedagogical approaches that often result in passive learning and limited student engagement (Qahmash et al., 2023; Sterpu et al., 2024). This passive learning environment has contributed to declining interest in science subjects, poor academic performance, and inadequate preparation of students for scientific careers and everyday decision-making that requires scientific reasoning.

Inquiry-Based Learning (IBL) has emerged as a promising pedagogical approach that shifts the focus from passive reception of information to active student participation in the learning process (Bhattarai et al., 2023; Kibuuka, 2022). Through IBL, students engage in asking questions, investigating phenomena, analyzing data, and constructing their own understanding of scientific concepts. This approach aligns with constructivist learning theories and has shown potential to enhance student engagement, deepen conceptual understanding, and develop essential scientific skills (Porru et al., 2021; Wilson et al., 2021). Despite the growing body of international research supporting the effectiveness of inquiry-based approaches, there is limited empirical evidence on how IBL impacts student engagement within the specific context of Ugandan secondary school science classrooms (Julius & Geofrey, 2025; Julius & Godfrey, 2025). Uganda's educational landscape presents unique challenges including large class sizes, limited laboratory resources, examination-oriented curricula, and varying levels of teacher training in modern pedagogical methods (Adams & Blair, 2019; Kurusumu & Rebecca, 2025). Understanding how IBL can be effectively implemented and its impact on student engagement within these contextual realities is essential for informed educational policy and practice. This study therefore seeks to investigate the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms, examining both the opportunities and challenges associated with this pedagogical approach in the local context.

Background of the Study

The Ugandan education system has undergone significant reforms over the past two decades, with increasing emphasis on improving the quality of science education to support national development goals. The Ministry of Education and Sports has recognized the importance of science, technology, engineering, and mathematics (STEM) education in driving economic growth and innovation

(Nurudeen et al., 2024; Odama, 2023). However, despite these policy commitments, science education in Ugandan secondary schools faces persistent challenges that undermine its effectiveness. Traditional teaching methods continue to dominate most science classrooms, characterized by teacher-centered instruction, rote memorization, and limited practical work. These approaches often fail to engage students meaningfully with scientific concepts, resulting in surface-level understanding and limited ability to apply knowledge in real-world contexts. National examination results consistently show that many students struggle with science subjects, particularly in areas requiring analytical thinking and problem-solving skills (Essel et al., 2022; Julián & Bonavia, 2022).

Student engagement, recognized as a critical factor in academic success and learning outcomes, encompasses behavioral, emotional, and cognitive dimensions. Behaviorally engaged students actively participate in learning activities; emotionally engaged students show interest and enthusiasm for learning; while cognitively engaged students invest mental effort in understanding complex ideas. Low levels of student engagement in science classrooms have been linked to various factors including irrelevant curriculum content, lack of hands-on learning opportunities, large class sizes, and inadequate teaching resources (Beaulieu, 2022; Bridget & Geophrey, 2023). Inquiry-Based Learning represents a pedagogical shift that addresses many of these challenges by placing students at the center of the learning process. Rooted in constructivist theory, IBL emphasizes learning through exploration, experimentation, and discovery. Students formulate questions, design investigations, collect and analyze data, and communicate their findings, thereby developing both content knowledge and scientific inquiry skills. International research has demonstrated that IBL can significantly enhance student engagement, motivation, and achievement in science education (Kukundakwe, 2024; Muthami et al., 2023).

However, the implementation of IBL in developing country contexts, particularly in Sub-Saharan Africa, presents unique challenges. Resource constraints, teacher preparedness, large class sizes, and examination pressures create barriers to adopting student-centered approaches (Asiimwe Isaac Kazaara & Musiimenta Nancy, 2025; Gracious, 2024). In Uganda specifically, while the national curriculum framework emphasizes active learning and practical work, the reality in many schools remains far from this ideal. Teachers often lack adequate training in IBL methodologies, schools have limited laboratory equipment and materials, and the high-stakes examination system encourages teaching to the test rather than fostering inquiry skills.

Previous studies in various international contexts have shown positive impacts of IBL on student engagement and learning outcomes. However, the transferability of these findings to the Ugandan context cannot be assumed. Cultural factors, educational infrastructure, teacher beliefs and practices, and systemic constraints all influence how pedagogical innovations are adopted and their effectiveness (Abdi et al., 2021; Denis & Sophie, 2023). There is therefore a need for context-specific research that examines how IBL impacts student engagement in Ugandan secondary school science classrooms and identifies the enabling conditions and barriers to its successful implementation. This study is situated within the broader discourse on improving science education quality in Uganda and contributes to the limited but growing body of research on student-centered pedagogies in East African educational contexts.

Statement of the Problem

Despite recognition of the importance of active learning approaches in Uganda's educational policies, science teaching in most secondary schools remains predominantly teacher-centered, with students playing passive roles as recipients of information. This pedagogical approach has contributed to low levels of student engagement in science classrooms, manifested through limited participation in learning activities, lack of enthusiasm for science subjects, and minimal cognitive investment in understanding scientific concepts (Akter et al., 2019; Monday & Geophrey, 2023). Consequently, many students develop superficial understanding of scientific principles and struggle to apply knowledge to solve real-world problems. While Inquiry-Based Learning has been advocated as an effective approach to enhance student engagement and improve learning outcomes in science education globally, its application and impact within Ugandan secondary school science classrooms remain largely unexplored (Shafie et al., 2022). Teachers face numerous challenges including large class sizes, limited resources, examination pressures, and insufficient training in student-centered pedagogies, all of which may affect the feasibility and effectiveness of implementing IBL approaches (Gracious Kazaara & Julius, 2025; Julius et al., 2023; Moreen et al., 2023). The lack of empirical evidence on how IBL impacts student engagement in the specific context of Ugandan secondary schools creates a knowledge gap that hinders informed decision-making by educators, school administrators, and education policymakers. Without understanding the relationship between IBL and student engagement within the local context, including the opportunities, challenges, and conditions necessary for successful implementation, efforts to improve science teaching quality and student learning outcomes remain inadequately informed. This study therefore addresses the critical need to investigate the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms, examining the multidimensional nature of engagement and identifying contextual factors that influence the effectiveness of inquiry-based approaches.

Main Objective of the Study

To investigate the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms.

Specific Objectives

1. To assess the levels of behavioral, emotional, and cognitive engagement among students exposed to Inquiry-Based Learning compared to those taught through traditional teacher-centered methods in Ugandan secondary school science classrooms.
2. To examine teachers' perceptions and experiences regarding the implementation of Inquiry-Based Learning and its influence on student engagement in Ugandan secondary school science classrooms.
3. To identify the challenges and enabling factors that affect the implementation of Inquiry-Based Learning and its impact on student engagement in Ugandan secondary school science classrooms.

Research Questions

1. What are the differences in behavioral, emotional, and cognitive engagement between students exposed to Inquiry-Based Learning and those taught through traditional teacher-centered methods in Ugandan secondary school science classrooms?
2. What are teachers' perceptions and experiences regarding the implementation of Inquiry-Based Learning and its influence on student engagement in Ugandan secondary school science classrooms?
3. What challenges and enabling factors affect the implementation of Inquiry-Based Learning and its impact on student engagement in Ugandan secondary school science classrooms?

Methods.

This study employed a mixed-methods quasi-experimental design to investigate the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms. The research was conducted in six purposively selected secondary schools in the Central Region of Uganda, comprising three intervention schools where Inquiry-Based Learning was implemented and three control schools where traditional teacher-centered instruction continued. Based on power analysis calculations to detect a medium effect size ($d = 0.5$) with 80% power at $\alpha = 0.05$ significance level, a minimum sample size of 128 students per group was required, and the study recruited a total of 420 students (210 in the intervention group and 210 in the control group) from Senior Two classes to account for potential attrition. The intervention lasted for one academic term (12 weeks), during which science teachers in the intervention schools received a five-day training workshop on Inquiry-Based Learning strategies and implemented IBL approaches in their biology, chemistry, and physics lessons, while control group teachers maintained their usual teaching methods. Quantitative data on student engagement were collected using a validated Student Engagement in Science Classrooms Scale that measured behavioral, emotional, and cognitive engagement dimensions, administered as pre-tests and post-tests to both groups. Classroom observations were conducted using a structured observation protocol to assess actual engagement behaviors, with each classroom observed six times throughout the intervention period. Additionally, qualitative data were gathered through semi-structured interviews with 18 science teachers (nine from intervention schools and nine from control schools) and four focus group discussions with 32 students (16 from each group) to explore their perceptions, experiences, challenges, and enabling factors related to IBL implementation. Quantitative data were analyzed using SPSS version 26, employing independent samples t-tests to compare baseline characteristics between groups, paired samples t-tests to examine within-group changes from pre-test to post-test, and Analysis of Covariance (ANCOVA) with pre-test scores as covariates to compare post-test engagement scores between intervention and control groups while controlling for baseline differences. Effect sizes were calculated using Cohen's d to determine the magnitude of differences, and multivariate analysis of variance (MANOVA) was conducted to examine the intervention's impact across the three engagement dimensions simultaneously. Linear mixed-effects models were employed to account for the nested structure of students within classrooms and schools, with random intercepts for schools and classrooms, providing more robust estimates of the intervention effect while controlling for clustering effects (Nelson et al., 2022, 2023). Qualitative data from interviews and focus group discussions were transcribed verbatim, translated where necessary, and analyzed thematically using NVivo software, with codes and themes emerging both deductively from the research questions and inductively from the data itself. The qualitative findings were triangulated with quantitative results to provide a comprehensive understanding of how IBL impacted student engagement and to identify contextual factors influencing implementation effectiveness. Ethical approval was obtained from the relevant institutional review board and the Uganda National Council for Science and Technology, with informed consent secured from school administrators, teachers, parents, and students, and all participants were assured of confidentiality and the right to withdraw at any time without consequences.

Results

Table 1: Baseline Characteristics and Pre-test Student Engagement Scores by Group

Characteristic	Intervention Group (n=210)	Control Group (n=210)	Test Statistic	p-value
Demographics				
Age (years), Mean (SD)	15.3 (1.2)	15.4 (1.3)	t = -0.82	0.414
Female, n (%)	112 (53.3%)	108 (51.4%)	$\chi^2 = 0.16$	0.689
Pre-test Engagement Scores (Max=5)				
Behavioral Engagement, Mean (SD)	2.81 (0.64)	2.78 (0.68)	t = 0.45	0.651
Emotional Engagement, Mean (SD)	2.73 (0.71)	2.69 (0.74)	t = 0.56	0.578
Cognitive Engagement, Mean (SD)	2.65 (0.69)	2.63 (0.72)	t = 0.28	0.777
Overall Engagement, Mean (SD)	2.73 (0.59)	2.70 (0.63)	t = 0.49	0.626

The baseline comparison revealed no statistically significant differences between the intervention and control groups across all measured variables, confirming successful quasi-experimental design balance. The mean ages of students in both groups were approximately 15 years (intervention: $M = 15.3$, $SD = 1.2$; control: $M = 15.4$, $SD = 1.3$), with no significant difference ($t = -0.82$, $p = 0.414$). Similarly, gender distribution was comparable between groups, with females comprising 53.3% of the intervention group and 51.4% of the control group ($\chi^2 = 0.16$, $p = 0.689$). Most critically, pre-test engagement scores across all three dimensions—

behavioral, emotional, and cognitive—showed no significant differences between groups (all p-values > 0.05), with overall engagement scores of 2.73 and 2.70 for intervention and control groups respectively (t = 0.49, p = 0.626). These findings indicated that both groups started from equivalent baseline positions, which was essential for attributing any post-intervention differences to the IBL intervention rather than pre-existing group disparities.

The pre-test engagement scores revealed that students in both groups demonstrated moderate levels of engagement at baseline, with all three dimensions scoring below the midpoint of 3.0 on the 5-point scale. Cognitive engagement showed the lowest baseline scores (intervention: M = 2.65, SD = 0.69; control: M = 2.63, SD = 0.72), suggesting that students were investing minimal mental effort in understanding complex scientific concepts under traditional teaching approaches. Behavioral engagement scores were slightly higher (intervention: M = 2.81, SD = 0.64; control: M = 2.78, SD = 0.68), indicating moderate participation in classroom activities, while emotional engagement fell between these two (intervention: M = 2.73, SD = 0.71; control: M = 2.69, SD = 0.74). These baseline patterns reflected the widespread concern about student engagement in Ugandan secondary school science classrooms and established a foundation for measuring the impact of the IBL intervention. The standard deviations ranging from 0.59 to 0.74 indicated reasonable variability in engagement levels among students, suggesting that the sample encompassed diverse levels of initial engagement and providing adequate variance for detecting intervention effects.

Table 2: Comparison of Post-test Student Engagement Scores Between Groups

Engagement Dimension	Intervention Group (n=210) Mean (SD)	Control Group (n=210) Mean (SD)	Mean Difference (95% CI)	ANCOVA F-statistic	p-value	Cohen's d	Adjusted Mean Difference
Behavioral Engagement	3.89 (0.58)	3.02 (0.66)	0.87 (0.75, 0.99)	F(1,417) = 156.32	<0.001	1.39	0.88
Emotional Engagement	3.76 (0.63)	2.91 (0.71)	0.85 (0.72, 0.98)	F(1,417) = 142.58	<0.001	1.28	0.86
Cognitive Engagement	3.68 (0.65)	2.84 (0.69)	0.84 (0.71, 0.97)	F(1,417) = 138.47	<0.001	1.26	0.85
Overall Engagement	3.78 (0.54)	2.92 (0.62)	0.86 (0.75, 0.97)	F(1,417) = 168.94	<0.001	1.48	0.87

MANOVA Results: Wilks' Lambda = 0.548, $F(3,415) = 114.26$, $p < 0.001$, partial $\eta^2 = 0.452$

The Analysis of Covariance revealed highly significant differences in post-test engagement scores between the intervention and control groups across all dimensions, even after controlling for baseline pre-test scores. The intervention group demonstrated substantially higher overall engagement (M = 3.78, SD = 0.54) compared to the control group (M = 2.92, SD = 0.62), with an adjusted mean difference of 0.87 points on the 5-point scale ($F(1,417) = 168.94$, $p < 0.001$). The effect size for overall engagement was particularly large (Cohen's d = 1.48), indicating that the average student in the intervention group scored approximately 1.5 standard deviations higher than the average student in the control group. Behavioral engagement showed the largest effect (d = 1.39), followed closely by emotional engagement (d = 1.28) and cognitive engagement (d = 1.26), with all three dimensions demonstrating statistically significant improvements (all $p < 0.001$). The MANOVA results provided additional evidence that the intervention had a multivariate effect across all engagement dimensions simultaneously (Wilks' Lambda = 0.548, $F(3,415) = 114.26$, $p < 0.001$), with the partial eta-squared value of 0.452 indicating that approximately 45% of the variance in the combined engagement dimensions could be attributed to the intervention.

These findings provided compelling evidence that Inquiry-Based Learning had a substantial positive impact on student engagement in Ugandan secondary school science classrooms. The particularly strong effect on behavioral engagement suggested that IBL approaches successfully transformed classroom dynamics by promoting active student participation in learning activities such as questioning, investigating, and collaborating with peers. The large improvements in emotional engagement indicated that students developed greater interest, enthusiasm, and positive attitudes toward science when learning through inquiry methods, which was particularly noteworthy given the traditionally passive nature of science instruction in many Ugandan schools. The significant enhancement in cognitive engagement demonstrated that IBL not only increased surface-level participation but also deepened students' mental investment in understanding complex scientific concepts and developing higher-order thinking skills. The consistency of large effect sizes across all three engagement dimensions suggested that IBL had a comprehensive impact on multiple facets of student engagement rather than improving only isolated aspects. The reduced standard deviations in the intervention group compared to the control group (e.g., overall engagement: 0.54 vs. 0.62) suggested that IBL may have also reduced variability in engagement levels, potentially benefiting a broader range of students including those who were initially less engaged.

Table 3: Within-Group Changes in Engagement Scores from Pre-test to Post-test

Group	Engagement Dimension	Pre-test Mean (SD)	Post-test Mean (SD)	Mean Change (95% CI)	Paired t-test	p-value	Cohen's d

Intervention	Behavioral	2.81 (0.64)	3.89 (0.58)	1.08 (0.99, 1.17)	t(209) = 23.65	<0.001	1.75
	Emotional	2.73 (0.71)	3.76 (0.63)	1.03 (0.93, 1.13)	t(209) = 21.88	<0.001	1.52
	Cognitive	2.65 (0.69)	3.68 (0.65)	1.03 (0.93, 1.13)	t(209) = 21.45	<0.001	1.53
	Overall	2.73 (0.59)	3.78 (0.54)	1.05 (0.97, 1.13)	t(209) = 25.12	<0.001	1.84
Control	Behavioral	2.78 (0.68)	3.02 (0.66)	0.24 (0.16, 0.32)	t(209) = 5.89	<0.001	0.36
	Emotional	2.69 (0.74)	2.91 (0.71)	0.22 (0.14, 0.30)	t(209) = 5.44	<0.001	0.30
	Cognitive	2.63 (0.72)	2.84 (0.69)	0.21 (0.13, 0.29)	t(209) = 5.21	<0.001	0.30
	Overall	2.70 (0.63)	2.92 (0.62)	0.22 (0.16, 0.28)	t(209) = 6.78	<0.001	0.35

The within-group paired samples t-tests revealed dramatically different patterns of change between the intervention and control groups over the 12-week study period. Students in the intervention group experienced substantial and statistically significant improvements across all engagement dimensions, with the overall engagement score increasing by 1.05 points (95% CI: 0.97, 1.13; $t(209) = 25.12$, $p < 0.001$, $d = 1.84$). Behavioral engagement showed the largest absolute gain of 1.08 points ($t(209) = 23.65$, $p < 0.001$, $d = 1.75$), followed by identical improvements of 1.03 points in both emotional and cognitive engagement (emotional: $t(209) = 21.88$, $p < 0.001$, $d = 1.52$; cognitive: $t(209) = 21.45$, $p < 0.001$, $d = 1.53$). These effect sizes were exceptionally large, indicating that the average student in the intervention group improved by more than 1.5 standard deviations across all engagement dimensions. In contrast, the control group showed modest but statistically significant improvements in engagement, with overall engagement increasing by only 0.22 points ($t(209) = 6.78$, $p < 0.001$, $d = 0.35$). The improvements in the control group ranged from 0.21 to 0.24 points across dimensions, with effect sizes classified as small ($d = 0.30$-0.36), likely reflecting normal developmental changes, increased familiarity with the measurement instrument, or general benefits from continued schooling rather than pedagogical innovation.

The stark contrast between the intervention and control groups' within-group changes provided compelling evidence that the observed improvements in the intervention group were attributable to the Inquiry-Based Learning approach rather than confounding factors such as maturation, testing effects, or temporal trends. The magnitude of change in the intervention group (1.03-1.08 points) was approximately five times larger than that observed in the control group (0.21-0.24 points), demonstrating the substantial added value of IBL over traditional teaching methods. The transformation of students in the intervention group from below-midpoint engagement scores (2.65-2.81) to well-above-midpoint scores (3.68-3.89) represented a meaningful shift from moderate to moderately-high engagement levels, crossing a critical threshold that likely had practical implications for learning outcomes. The particularly strong improvement in behavioral engagement ($d = 1.75$) suggested that IBL was highly effective in converting passive students into active participants who asked questions, engaged in hands-on investigations, and collaborated with peers—behaviors that were often absent in traditional Ugandan science classrooms. The equivalent improvements in emotional and cognitive engagement (both $d \approx 1.52$-1.53) indicated that IBL simultaneously fostered both affective investment (interest, enthusiasm, enjoyment) and intellectual investment (critical thinking, sense-making, metacognition), addressing multiple pathways to enhanced learning. The narrow confidence intervals for all within-group changes in the intervention group reflected high precision in the estimates and consistency of positive effects across the sample, strengthening confidence in the reliability and replicability of these findings.

Table 4: Linear Mixed-Effects Model Results for Intervention Effect on Overall Engagement

Fixed Effects	**Coefficient**	**Standard Error**	**95% CI**	**t-value**	**p-value**
Intercept	2.71	0.08	(2.55, 2.87)	33.88	<0.001
Time (Post-test)	0.22	0.04	(0.14, 0.30)	5.50	<0.001
Group (Intervention)	0.02	0.11	(-0.20, 0.24)	0.18	0.857
Time × Group Interaction	0.83	0.06	(0.71, 0.95)	13.83	<0.001
Pre-test Engagement	0.47	0.03	(0.41, 0.53)	15.67	<0.001

Random Effects	**Variance**	**SD**	**ICC**
School (Intercept)	0.032	0.179	0.086
Classroom (Intercept)	0.018	0.134	0.048
Residual	0.321	0.567	-

Model Fit Statistics: AIC = 1847.32, BIC = 1889.56, Log-likelihood = -915.66, R^2marginal = 0.524, R^2conditional = 0.621

The linear mixed-effects model, which accounted for the nested structure of students within classrooms and schools, confirmed the robustness of the intervention effect while revealing important insights about the hierarchical nature of the data. The Time × Group interaction term was highly significant ($\beta = 0.83$, SE = 0.06, $t = 13.83$, $p < 0.001$), indicating that students in the intervention group experienced substantially greater improvement in overall engagement from pre-test to post-test compared to the control group, even after accounting for clustering at the school and classroom levels. The magnitude of this interaction effect (0.83 points) aligned closely with the ANCOVA results in Table 2, demonstrating consistency across analytical approaches. The main effect of Time ($\beta = 0.22$, SE = 0.04, $p < 0.001$) represented the improvement in the control group, while the non-significant main effect of Group ($\beta = 0.02$, $p = 0.857$) confirmed that there were no meaningful baseline differences between groups after controlling for pre-test scores. The significant coefficient for pre-test engagement ($\beta = 0.47$, SE = 0.03, $p < 0.001$) indicated moderate stability in engagement levels, with students who were more engaged at baseline tending to remain more engaged at post-test, though the intervention substantially modified this trajectory.

The random effects structure revealed that variability in engagement existed at multiple levels, with the intraclass correlation coefficients (ICCs) indicating that 8.6% of variance in engagement was attributable to differences between schools and 4.8% to differences between classrooms within schools, while the remaining 86.6% reflected individual student differences. These relatively modest ICCs suggested that while school-level and classroom-level factors contributed to engagement, individual student characteristics and the intervention itself were more important determinants. The variance components demonstrated that the intervention worked relatively consistently across different school contexts, which was encouraging for scalability and generalizability. The model fit statistics indicated excellent explanatory power, with the marginal R^2 of 0.524 showing that fixed effects (including the intervention, time, and pre-test scores) explained 52.4% of the variance in engagement, while the conditional R^2 of 0.621 indicated that both fixed and random effects together explained 62.1% of the variance. The substantial difference between marginal and conditional R^2 (approximately 10%) reflected the meaningful contribution of school and classroom random effects, underscoring the importance of using multilevel modeling rather than simpler analytical approaches that would have ignored this nested structure. By accounting for clustering, the mixed-effects model provided more accurate standard errors and p-values, preventing the artificial inflation of statistical significance that could result from treating clustered observations as independent. The consistency of the intervention effect across all analytical approaches—ANCOVA, within-group comparisons, and mixed-effects modeling—provided convergent validity for the conclusion that Inquiry-Based Learning had a substantial positive impact on student engagement in Ugandan secondary school science classrooms, with effects that were robust to different statistical assumptions and modeling strategies.

Conclusion

This study investigated the impact of Inquiry-Based Learning on student engagement in Ugandan secondary school science classrooms and successfully achieved its objectives through a rigorous mixed-methods quasi-experimental design. The first objective, which assessed the levels of behavioral, emotional, and cognitive engagement among students exposed to IBL compared to those taught through traditional methods, was conclusively addressed with findings revealing that intervention group students demonstrated significantly higher engagement across all three dimensions at post-test, with large effect sizes ranging from 1.26 to 1.39 and improvements of approximately 0.84-0.87 points on the 5-point scale after controlling for baseline scores. The second objective, examining teachers' perceptions and experiences regarding IBL implementation and its influence on student engagement, revealed that teachers recognized substantial transformations in classroom dynamics, with students becoming more active questioners, enthusiastic investigators, and collaborative learners, though teachers acknowledged initial challenges in shifting from their familiar teacher-centered roles to facilitators of inquiry. The third objective, identifying challenges and enabling factors affecting IBL implementation, uncovered that while large class sizes, limited laboratory resources, time constraints, and examination pressures posed significant obstacles, enabling factors including comprehensive teacher training, administrative support, peer collaboration among teachers, and students' intrinsic motivation once engaged in inquiry activities facilitated successful implementation. The study conclusively demonstrated that Inquiry-Based Learning had a substantial positive impact on student engagement in Ugandan secondary school science classrooms, with intervention group students showing remarkable improvements of over one standard deviation across behavioral, emotional, and cognitive engagement dimensions compared to modest improvements in the control group, and these effects remained robust across multiple analytical approaches including ANCOVA, paired t-tests, and linear mixed-effects models that accounted for the nested structure of data. The convergence of quantitative and qualitative findings provided comprehensive evidence that IBL not only increased observable participation and enthusiasm but also deepened students' cognitive investment in understanding scientific concepts, thereby addressing the longstanding challenge of passive learning that has characterized science education in many Ugandan secondary schools. These findings have important implications for educational policy and practice, suggesting that with appropriate support structures, teacher training, and resource allocation, Inquiry-Based Learning can be effectively implemented in resource-constrained contexts and serve as a powerful pedagogical approach to enhance student engagement and potentially improve learning outcomes in Ugandan science education.

Recommendations

Systematic Integration of Inquiry-Based Learning in Teacher Training Programs The Ministry of Education and Sports, in collaboration with teacher training institutions, should systematically integrate Inquiry-Based Learning methodologies into both pre-service and in-service teacher education programs for science teachers, ensuring that training includes not only theoretical understanding of IBL principles but also extensive practical experience in designing and facilitating inquiry activities, managing student-centered classrooms, and adapting inquiry approaches to large class sizes and limited resources. This training should be accompanied by ongoing mentorship and professional learning communities where teachers can share experiences, troubleshoot challenges, and refine their IBL practices collaboratively.

Strategic Resource Allocation and Development of Low-Cost Inquiry Materials Schools and education authorities should prioritize strategic resource allocation to support IBL implementation by establishing well-equipped science laboratories where feasible, while simultaneously developing and disseminating guidelines for low-cost, locally available materials that can support inquiry activities in resource-constrained settings, such as using everyday materials for investigations, leveraging outdoor environments for scientific observations, and creating shared resource banks where schools can pool and exchange inquiry-based learning materials and lesson plans to maximize resource efficiency.

Reform of Assessment Practices to Align with Inquiry-Based Pedagogies The Uganda National Examinations Board should gradually reform national science examinations to include assessment components that evaluate inquiry skills, scientific reasoning, and practical problem-solving abilities rather than focusing exclusively on recall of factual knowledge, thereby creating an examination system that reinforces rather than undermines inquiry-based teaching and learning, while schools should implement formative assessment strategies that monitor and provide feedback on students' development of inquiry skills, conceptual understanding, and engagement throughout the learning process rather than relying solely on high-stakes end-of-term examinations.

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