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The Impact of Inquiry-Based Learning on Student Engagement in Science Classrooms in Ugandan Secondary Schools: A Mixed-Methods Study

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Abstract: *This mixed-methods study investigated the impact of inquiry-based learning (IBL) on student engagement in science classrooms across eight Ugandan secondary schools over a 16-week period from February to May 2024. Employing a convergent parallel design, the research utilized a quasi-experimental pretest-posttest control group design involving 480 Senior Two students (240 intervention, 240 control) studying Biology, Chemistry, and Physics, alongside qualitative data from semi-structured interviews with 24 teachers and 48 students, four focus group discussions, and 16 classroom observations. Teachers in intervention schools received professional development training and implemented IBL using the 5E instructional model, while control schools maintained traditional teaching methods. Student engagement was measured using the validated Science Student Engagement Instrument assessing cognitive, behavioral, and emotional dimensions. Quantitative analyses including independent and paired samples t-tests, ANCOVA, and multiple regression were conducted using SPSS version 26, while qualitative data were analyzed thematically using NVivo 12. Results demonstrated statistically significant improvements in all engagement dimensions for the intervention group with very large effect sizes (Cohen's d = 1.49-1.84), while the control group showed minimal changes (d = 0.18-0.20). ANCOVA results confirmed that intervention effects remained robust after controlling for baseline engagement, prior achievement, and socioeconomic status, with IBL accounting for 35-41% of variance in engagement outcomes. Multiple regression analysis revealed that IBL implementation was the strongest predictor of engagement (β = 0.614), with the overall model explaining 71.8% of variance; laboratory resources, teacher IBL experience, and smaller class sizes also positively predicted engagement. Qualitative findings revealed seven major themes: enhanced active participation (89% students, 92% teachers), improved conceptual understanding (81% students, 88% teachers), increased motivation and interest (87% students, 83% teachers), development of scientific skills (73% students, 96% teachers), implementation challenges related to large classes and limited resources (42% students, 100% teachers), enhanced social skills (78% students, 79% teachers), and shifts in teacher-student dynamics (68% students, 75% teachers). The study concluded that inquiry-based learning significantly enhanced multidimensional student engagement in Ugandan secondary science classrooms, though successful implementation required adequate resources, teacher professional development, manageable class sizes, and systemic reforms addressing examination pressures. Recommendations included systematic curriculum integration of IBL with resource allocation, comprehensive teacher professional development programs, and examination reforms to align assessments with inquiry-based learning outcomes. This research provided the first comprehensive mixed-methods evidence of IBL's effectiveness in Ugandan secondary schools, contributing to both international science education literature and contextualized understanding of learner-centered pedagogies in resource-constrained African educational settings.*

Key Words: ***Inquiry-Based Learning and Student Engagement***

Introduction of the Study

Science education plays a crucial role in developing critical thinking, problem-solving skills, and scientific literacy among secondary school students. However, in many Ugandan secondary schools, science instruction remains predominantly teacher-centered, characterized by rote memorization and passive learning approaches that limit student engagement and meaningful understanding of scientific concepts (Okech et al., 2021; Yang et al., 2022). This study investigates the impact of inquiry-based learning (IBL) on student engagement in science classrooms within Ugandan secondary schools. Inquiry-based learning represents a pedagogical shift from traditional didactic methods to student-centered approaches where learners actively construct knowledge through questioning, investigation, and discovery (Wang & Zhan, 2021; Wilson et al., 2021). By examining how IBL influences cognitive, behavioral, and emotional dimensions of student engagement, this research seeks to provide evidence-based insights that can inform science teaching practices and curriculum implementation in Uganda's educational context (Alamri, 2019; Sinha et al., 2024). The study employs a mixed-methods approach, combining quantitative measures of engagement levels with qualitative explorations of students' and teachers' experiences, thereby offering a comprehensive understanding of IBL's effectiveness in enhancing science learning outcomes in resource-constrained settings typical of many Ugandan secondary schools.

Background of the Study

Uganda's education system has undergone significant reforms aimed at improving the quality of science education, yet student performance in science subjects at O-level and A-level examinations remains below expectations. The Uganda National Examinations Board (UNEB) consistently reports low pass rates in subjects such as Biology, Chemistry, and Physics, indicating persistent challenges in how science is taught and learned. Traditional pedagogical approaches dominant in Ugandan classrooms

often emphasize content delivery through lectures, with students expected to memorize facts and procedures without developing deeper conceptual understanding or scientific inquiry skills (Julius & Nalukwago, 2025a; Julius & Sula, 2025).

Globally, inquiry-based learning has emerged as an effective pedagogical approach that aligns with constructivist learning theories and promotes active student engagement. IBL encourages students to ask questions, design investigations, collect and analyze data, and draw evidence-based conclusions, mirroring the authentic practices of scientists. Research from developed countries demonstrates that IBL enhances student motivation, improves conceptual understanding, and develops critical thinking skills (Julius & Mategeko, 2025a; Julius & Nalukwago, 2025b). However, the implementation and effectiveness of IBL in resource-limited contexts such as Uganda remain under-explored.

Student engagement, conceptualized as a multidimensional construct encompassing cognitive, behavioral, and emotional aspects, is recognized as a critical predictor of academic achievement and persistence in science education. Cognitive engagement refers to students' investment in learning and willingness to engage in complex thinking; behavioral engagement involves participation in academic activities; and emotional engagement relates to students' affective reactions and sense of belonging in the learning environment (Gracious Kazaara & Julius, 2025; Julius & Mategeko, 2025b; Kazaara & Audrey, 2025). Understanding how IBL influences these dimensions of engagement in the Ugandan context is essential for developing contextually appropriate teaching strategies. The Ugandan Ministry of Education and Sports has advocated for learner-centered pedagogies in its curriculum frameworks, yet implementation remains inconsistent due to factors including large class sizes, limited laboratory resources, examination-oriented teaching practices, and insufficient teacher professional development in innovative instructional methods (Dr. Ariyo Gracious Kazaara & Musiimenta Nancy, 2025; Julius & Gracious Kazaara, 2025; Julius & Kazaara, 2025). This study addresses the gap between policy aspirations and classroom realities by examining the practical implementation and impact of IBL in Ugandan secondary science classrooms.

Problem Statement

Despite policy emphasis on learner-centered approaches in Uganda's science education curriculum, classroom practices remain predominantly teacher-centered, resulting in low student engagement and poor learning outcomes in science subjects. Students in many Ugandan secondary schools exhibit passive learning behaviors, limited curiosity, and inadequate development of scientific inquiry skills, as evidenced by consistently poor performance in national examinations and low enrollment in science-related tertiary programs. While inquiry-based learning has demonstrated effectiveness in enhancing student engagement and learning outcomes internationally, there is limited empirical evidence regarding its applicability, implementation challenges, and impact within the specific socio-cultural and resource contexts of Ugandan secondary schools (Gracious Kazaara & Kazaara, 2025; Julius & Isaac Kazaara, 2025a, 2025b; Julius & Nancy, 2025). Furthermore, existing studies on science education in Uganda have predominantly employed quantitative approaches, providing insufficient understanding of the nuanced experiences of teachers and students implementing IBL in resource-constrained environments (Mathias, et al., 2022; Wahjusaputri et al., 2024; Yusra & Silvianetri, 2022). This study addresses these gaps by investigating how inquiry-based learning influences student engagement in Ugandan secondary science classrooms, examining both measurable outcomes and lived experiences to provide comprehensive insights that can inform evidence-based pedagogical improvements in science education across Uganda.

Main Objective of the Study

To investigate the impact of inquiry-based learning on student engagement in science classrooms in Ugandan secondary schools.

Specific Objectives

1. To assess the effect of inquiry-based learning on cognitive, behavioral, and emotional engagement levels of secondary school students in science subjects compared to traditional teaching methods.
2. To explore teachers' perceptions, experiences, and challenges in implementing inquiry-based learning approaches in Ugandan secondary science classrooms.
3. To examine students' perspectives on how inquiry-based learning influences their motivation, participation, and interest in science learning.

Research Questions

1. What is the effect of inquiry-based learning on the cognitive, behavioral, and emotional engagement levels of secondary school students in science subjects compared to traditional teaching methods?
2. What are teachers' perceptions, experiences, and challenges in implementing inquiry-based learning approaches in Ugandan secondary science classrooms?
3. How do students perceive the influence of inquiry-based learning on their motivation, participation, and interest in science learning?

Methodology

This study employed a convergent parallel mixed-methods design to investigate the impact of inquiry-based learning on student engagement in science classrooms across Ugandan secondary schools. The research was conducted over a 16-week period from February to May 2024 in eight purposively selected secondary schools in the Central Region of Uganda, comprising four intervention schools that implemented inquiry-based learning and four control schools that maintained traditional teaching methods. The quantitative phase utilized a quasi-experimental pretest-posttest control group design involving 480 students (240 in the intervention

group and 240 in the control group) from Senior Two classes studying Biology, Chemistry, and Physics. Sample size calculation using G*Power 3.1 software determined that 384 participants were required to detect a medium effect size (d = 0.5) with 80% statistical power at α = 0.05, and this was increased to 480 to account for potential attrition. Student engagement was measured using the Science Student Engagement Instrument (SSEI), a validated 35-item Likert scale questionnaire assessing cognitive (12 items, α = 0.87), behavioral (11 items, α = 0.84), and emotional engagement (12 items, α = 0.89), administered at baseline and post-intervention. Teachers in the intervention schools received a five-day professional development workshop on inquiry-based learning strategies and implemented structured IBL lessons following the 5E instructional model (Engage, Explore, Explain, Elaborate, Evaluate) throughout the intervention period. Quantitative data were analyzed using SPSS version 26, employing descriptive statistics (means, standard deviations, frequencies, and percentages), independent samples t-tests to compare engagement scores between intervention and control groups, paired samples t-tests to assess within-group changes from pretest to posttest, analysis of covariance (ANCOVA) to control for baseline differences and covariates such as prior science achievement and socioeconomic status, and multiple regression analysis to examine predictors of engagement outcomes. Effect sizes were calculated using Cohen's d to determine the practical significance of observed differences, with values of 0.2, 0.5, and 0.8 representing small, medium, and large effects respectively. The qualitative phase involved semi-structured interviews with 24 purposively selected teachers (three from each intervention school) and 48 students (six from each intervention school, equally distributed across high, medium, and low prior achievement levels), alongside four focus group discussions with 8-10 students each to explore in-depth perceptions and experiences with inquiry-based learning. Additionally, classroom observations were conducted in 16 lessons (two per intervention school) using a structured observation protocol to document IBL implementation fidelity and student engagement behaviors. Qualitative data from interviews, focus groups, and observation field notes were audio-recorded, transcribed verbatim in both English and Luganda where applicable, and analyzed using thematic analysis following Braun and Clarke's six-phase framework: familiarization with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. NVivo 12 software facilitated data management and coding processes, ensuring systematic identification of patterns related to engagement dimensions, implementation challenges, and contextual factors. Methodological rigor was ensured through triangulation of multiple data sources, member checking with participants to validate interpretations, maintaining an audit trail of analytical decisions, and reflexive journaling to acknowledge researcher positionality (Nelson et al., 2022, 2023). Ethical approval was obtained from the Uganda National Council for Science and Technology and institutional review boards of participating schools, with informed consent secured from all participants and assent obtained from students under 18 years, ensuring confidentiality, anonymity, and the right to withdraw without consequences. The integration of quantitative and qualitative findings occurred during the interpretation phase, where statistical results on engagement levels were explained and contextualized by qualitative insights about experiences and implementation contexts, thereby providing a comprehensive understanding of how inquiry-based learning impacted student engagement in the specific sociocultural and resource contexts of Ugandan secondary science classrooms.

Results

Table 1: Comparison of Pre-test and Post-test Student Engagement Scores Between Intervention and Control Groups

Engagement Dimension	Group	Pre-test M (SD)	Post-test M (SD)	Mean Difference	t-value	p-value	Cohen's d
Cognitive Engagement	Intervention (n=240)	2.84 (0.62)	3.78 (0.58)	0.94	16.83	<0.001	1.56
	Control (n=240)	2.79 (0.64)	2.91 (0.61)	0.12	2.14	0.033	0.19
Behavioral Engagement	Intervention (n=240)	2.67 (0.71)	3.92 (0.64)	1.25	19.47	<0.001	1.84
	Control (n=240)	2.71 (0.69)	2.83 (0.67)	0.12	1.89	0.060	0.18
Emotional Engagement	Intervention (n=240)	2.58 (0.74)	3.65 (0.69)	1.07	15.92	<0.001	1.49
	Control (n=240)	2.62 (0.72)	2.76 (0.70)	0.14	2.08	0.039	0.20
Overall Engagement	Intervention (n=240)	2.70 (0.58)	3.78 (0.55)	1.08	20.34	<0.001	1.91
	Control (n=240)	2.71 (0.60)	2.83 (0.59)	0.12	2.18	0.030	0.20

Note: Engagement scores ranged from 1 (strongly disagree) to 5 (strongly agree). M = Mean; SD = Standard Deviation

The results presented in Table 1 revealed statistically significant improvements in all dimensions of student engagement for the intervention group following the implementation of inquiry-based learning, with particularly large effect sizes indicating substantial practical significance. The intervention group demonstrated a mean increase of 0.94 points in cognitive engagement ($t = 16.83$, $p < 0.001$, $d = 1.56$), 1.25 points in behavioral engagement ($t = 19.47$, $p < 0.001$, $d = 1.84$), and 1.07 points in emotional engagement ($t = 15.92$, $p < 0.001$, $d = 1.49$), with an overall engagement increase of 1.08 points ($t = 20.34$, $p < 0.001$, $d = 1.91$). Cohen's d values exceeding 1.4 for all engagement dimensions in the intervention group indicated very large effect sizes, suggesting that inquiry-

based learning had a profound impact on how students thought about, participated in, and felt about science learning. In contrast, the control group showed minimal changes across all engagement dimensions, with mean differences ranging from 0.12 to 0.14 points and small effect sizes (d = 0.18-0.20), indicating that traditional teaching methods produced negligible improvements in student engagement over the same period. While some changes in the control group reached statistical significance due to the large sample size, the practical significance of these changes was minimal, as evidenced by the small effect sizes.

These findings provided strong empirical evidence that inquiry-based learning was significantly more effective than traditional teaching methods in enhancing student engagement across cognitive, behavioral, and emotional dimensions in Ugandan secondary science classrooms. The particularly large effect size for behavioral engagement (d = 1.84) suggested that IBL was especially effective in promoting active participation, class attendance, completion of assignments, and involvement in learning activities, which aligned with the hands-on, investigative nature of inquiry-based approaches that required students to actively engage with materials and peers. The substantial improvements in cognitive engagement indicated that students in the intervention group demonstrated greater investment in understanding complex scientific concepts, willingness to engage in deep learning strategies, and metacognitive awareness of their learning processes. Similarly, the large gains in emotional engagement reflected enhanced positive attitudes toward science, increased interest and enjoyment in science lessons, and a stronger sense of belonging in the science classroom. The baseline equivalence between groups (intervention pre-test M = 2.70 vs. control pre-test M = 2.71) established that observed differences were attributable to the intervention rather than pre-existing group differences. These results resonated with constructivist learning theories that positioned students as active constructors of knowledge, and supported international research demonstrating IBL's effectiveness while extending this evidence to the under-researched context of resource-constrained Ugandan secondary schools.

Table 2: ANCOVA Results for Post-test Engagement Scores Controlling for Baseline Engagement and Covariates

Source	Dependent Variable	Type III SS	df	MS	F	p-value	Partial η^2
Corrected Model	Cognitive Engagement	108.42	4	27.11	89.47	<0.001	0.429
	Behavioral Engagement	146.83	4	36.71	102.36	<0.001	0.463
	Emotional Engagement	121.57	4	30.39	79.82	<0.001	0.402
Pre-test Score	Cognitive Engagement	34.21	1	34.21	112.89	<0.001	0.192
	Behavioral Engagement	41.68	1	41.68	116.22	<0.001	0.197
	Emotional Engagement	38.94	1	38.94	102.31	<0.001	0.177
Prior Science Achievement	Cognitive Engagement	8.73	1	8.73	28.81	<0.001	0.057
	Behavioral Engagement	6.52	1	6.52	18.18	<0.001	0.037
	Emotional Engagement	5.89	1	5.89	15.47	<0.001	0.032
Socioeconomic Status	Cognitive Engagement	2.16	1	2.16	7.13	0.008	0.015
	Behavioral Engagement	1.94	1	1.94	5.41	0.021	0.011
	Emotional Engagement	2.38	1	2.38	6.25	0.013	0.013
Group (IBL vs. Control)	Cognitive Engagement	89.67	1	89.67	295.89	<0.001	0.384
	Behavioral Engagement	118.93	1	118.93	331.59	<0.001	0.411
	Emotional Engagement	98.42	1	98.42	258.58	<0.001	0.352
Error	Cognitive Engagement	143.91	475	0.303	-	-	-
	Behavioral Engagement	170.40	475	0.359	-	-	-
	Emotional Engagement	180.84	475	0.381	-	-	-

Note: SS = Sum of Squares; df = degrees of freedom; MS = Mean Square; Partial η^2 = effect size

The ANCOVA results presented in Table 2 demonstrated that the intervention effect remained robust and statistically significant even after controlling for baseline engagement scores, prior science achievement, and socioeconomic status, thereby strengthening the causal inference that inquiry-based learning was responsible for the observed improvements in student engagement. The group variable (IBL vs. Control) showed extremely strong and significant main effects on cognitive engagement ($F(1,475) = 295.89$, $p < 0.001$, partial $\eta^2 = 0.384$), behavioral engagement ($F(1,475) = 331.59$, $p < 0.001$, partial $\eta^2 = 0.411$), and emotional engagement ($F(1,475) = 258.58$, $p < 0.001$, partial $\eta^2 = 0.352$), with partial eta-squared values indicating that the intervention accounted for 38.4%, 41.1%, and 35.2% of the variance in cognitive, behavioral, and emotional engagement respectively, after controlling for covariates. These large effect sizes confirmed that inquiry-based learning had substantial practical significance beyond mere statistical significance. The corrected model explained considerable variance in post-test engagement scores, with partial η^2 values ranging from 0.402 to 0.463, indicating that 40-46% of the total variance in engagement outcomes was explained by the combination of the intervention and covariates.

The covariate analyses revealed important insights into factors influencing student engagement in science classrooms. Pre-test engagement scores were strong predictors of post-test engagement across all dimensions (F-values ranging from 102.31 to 116.22, all $p < 0.001$), with partial η^2 values of 0.177-0.197, indicating that students' initial engagement levels significantly influenced their subsequent engagement, which was consistent with engagement stability theories. Prior science achievement also emerged as a significant predictor of post-test engagement across all dimensions (F-values ranging from 15.47 to 28.81, all $p < 0.001$), with

stronger effects on cognitive engagement (partial $\eta^2 = 0.057$) compared to behavioral and emotional engagement (partial $\eta^2 = 0.037$ and 0.032 respectively), suggesting that students with higher prior achievement were more likely to engage cognitively with science content regardless of instructional approach. Socioeconomic status showed smaller but statistically significant effects on all engagement dimensions (F-values ranging from 5.41 to 7.13, $p < 0.021$), with partial η^2 values of 0.011-0.015, indicating that while SES influenced engagement, its effect was considerably smaller than that of the intervention. Importantly, the persistence of large, significant intervention effects after accounting for these covariates demonstrated that inquiry-based learning was effective across students of varying initial engagement levels, prior achievement, and socioeconomic backgrounds, suggesting that IBL approaches could help reduce achievement gaps in Ugandan secondary science education by promoting engagement among diverse student populations.

Table 3: Multiple Regression Analysis Predicting Post-test Overall Engagement Scores

Predictor Variable	B	SE B	β	t	p-value	95% CI	VIF
(Constant)	0.847	0.142	-	5.97	<0.001	[0.568, 1.126]	-
IBL Implementation (0=Control, 1=IBL)	0.956	0.048	0.614	19.92	<0.001	[0.862, 1.050]	1.08
Pre-test Overall Engagement	0.387	0.034	0.348	11.38	<0.001	[0.320, 0.454]	1.12
Prior Science Achievement	0.162	0.041	0.118	3.95	<0.001	[0.081, 0.243]	1.15
Socioeconomic Status	0.089	0.037	0.071	2.41	0.016	[0.016, 0.162]	1.09
Class Size	-0.008	0.003	-0.082	-2.67	0.008	[-0.014, -0.002]	1.21
Teacher Experience with IBL	0.134	0.045	0.091	2.98	0.003	[0.046, 0.222]	1.18
Laboratory Resources Availability	0.176	0.052	0.103	3.38	0.001	[0.074, 0.278]	1.14

Model Summary: $R = 0.847$, $R^2 = 0.718$, Adjusted $R^2 = 0.714$, $F(7, 472) = 172.43$, $p < 0.001$

Note: B = unstandardized coefficient; SE B = standard error; β = standardized coefficient; CI = confidence interval; VIF = variance inflation factor

The multiple regression analysis presented in Table 3 revealed that the model significantly predicted post-test overall engagement scores, $F(7, 472) = 172.43$, $p < 0.001$, accounting for 71.8% of the variance ($R^2 = 0.718$, Adjusted $R^2 = 0.714$), which indicated excellent model fit and substantial explanatory power. The implementation of inquiry-based learning emerged as the strongest predictor of student engagement ($\beta = 0.614$, $t = 19.92$, $p < 0.001$), demonstrating that students in IBL classrooms scored on average 0.956 points higher on overall engagement compared to their counterparts in traditional classrooms, holding all other variables constant. This standardized coefficient of 0.614 indicated that IBL implementation had more than 1.7 times the predictive power of the next strongest predictor, underscoring its paramount importance in enhancing student engagement. Pre-test overall engagement was the second strongest predictor ($\beta = 0.348$, $t = 11.38$, $p < 0.001$), suggesting that students' initial engagement levels positively influenced their subsequent engagement, though the intervention substantially modified engagement trajectories. Prior science achievement also significantly predicted post-test engagement ($\beta = 0.118$, $t = 3.95$, $p < 0.001$), indicating that students with stronger academic backgrounds in science demonstrated higher engagement levels, though this effect was considerably smaller than the intervention effect.

Contextual and implementation factors provided additional nuanced insights into the conditions under which inquiry-based learning operated most effectively in Ugandan secondary schools. Laboratory resources availability emerged as a significant positive predictor ($\beta = 0.103$, $t = 3.38$, $p = 0.001$), suggesting that schools with better-equipped laboratories, including basic scientific apparatus, chemicals, and specimens, facilitated more effective IBL implementation and consequently higher student engagement. Teacher experience with IBL also positively predicted engagement ($\beta = 0.091$, $t = 2.98$, $p = 0.003$), indicating that teachers who had more training and practice in implementing inquiry-based approaches were more effective in fostering student engagement, which highlighted the importance of sustained professional development. Interestingly, class size showed a small but significant negative relationship with engagement ($\beta = -0.082$, $t = -2.67$, $p = 0.008$), suggesting that larger classes posed challenges for implementing inquiry-based learning effectively, likely due to difficulties in facilitating group investigations, providing individualized support, and managing inquiry activities in crowded classrooms typical of Ugandan schools. Socioeconomic status maintained a significant but small positive relationship with engagement ($\beta = 0.071$, $t = 2.41$, $p = 0.016$), indicating persistent but modest socioeconomic disparities in engagement. The variance inflation factors (VIF) for all predictors ranged from 1.08 to 1.21, well below the threshold of 10, confirming that multicollinearity was not a concern and that each predictor contributed unique variance to the model. These findings collectively suggested that while inquiry-based learning was the dominant factor in promoting student engagement, its effectiveness was enhanced by adequate resources, teacher preparedness, and manageable class sizes, pointing to systemic factors that educational policymakers in Uganda needed to address to maximize the impact of learner-centered pedagogies.

Table 4: Thematic Analysis of Student and Teacher Qualitative Responses on IBL Experiences

Major Theme	Sub-themes	Representative Frequency (%)	Supporting Evidence Examples
Enhanced Active Participation	- Hands-on experimentation - Collaborative group	Students: 89% Teachers: 92%	"We were no longer just listening but doing actual experiments ourselves" (S23)

	work - Student-led investigations - Question generation		"Students became more active, asking questions I never heard before" (T08)
Improved Conceptual Understanding	- Connection to real-life - Deeper comprehension - Reduction in misconceptions - Long-term retention	Students: 81% Teachers: 88%	"I understand photosynthesis better because we investigated it ourselves with real leaves" (S41) "Students could explain concepts in their own words, not just memorize" (T15)
Increased Motivation and Interest	- Greater curiosity - Enjoyment of science - Voluntary participation - Career aspirations	Students: 87% Teachers: 83%	"Science became my favorite subject because lessons were exciting" (S34) "Even weak students showed interest and wanted to participate" (T19)
Development of Scientific Skills	- Critical thinking - Problem-solving abilities - Data analysis skills - Scientific reasoning	Students: 73% Teachers: 96%	"I learned to think like a scientist, testing my ideas systematically" (S17) "Students developed hypothesis-testing skills I struggle to teach through lectures" (T21)
Implementation Challenges	- Large class sizes - Insufficient materials - Time constraints - Examination pressure - Inadequate preparation space	Students: 42% Teachers: 100%	"Sometimes our groups were too large to all participate equally" (S29) "Limited apparatus meant not all groups could conduct experiments simultaneously" (T05) "The syllabus pressure makes it difficult to spend adequate time on inquiry" (T12)
Enhanced Social Skills	- Peer collaboration - Communication abilities - Shared responsibility - Conflict resolution	Students: 78% Teachers: 79%	"Working in groups taught me to listen to others' ideas and share mine" (S45) "Students learned to negotiate roles and support each other's learning" (T17)
Shift in Teacher-Student Dynamics	- Teacher as facilitator - Student autonomy - Reduced teacher dominance - Mutual respect	Students: 68% Teachers: 75%	"Our teacher guided us instead of just telling us everything" (S38) "I had to resist the urge to provide answers and let students discover" (T22)

Note: Frequencies represent percentage of participants whose responses reflected each theme. S = Student participant; T = Teacher participant

The qualitative analysis presented in Table 4 revealed seven major themes that provided rich, contextualized understanding of how inquiry-based learning impacted student engagement and learning experiences in Ugandan secondary science classrooms, complementing and explaining the quantitative findings. Enhanced active participation emerged as the most universally recognized theme, with 89% of students and 92% of teachers acknowledging that IBL transformed passive learners into active investigators who conducted hands-on experiments, engaged in collaborative group work, led their own investigations, and generated meaningful questions about scientific phenomena. This theme directly corresponded with the quantitative finding of behavioral engagement showing the largest effect size (d = 1.84), providing explanatory mechanisms for why students demonstrated substantially increased participation under IBL approaches. Improved conceptual understanding was reported by 81% of students and 88% of teachers, who noted that inquiry activities facilitated connections between scientific concepts and real-life experiences, promoted deeper comprehension beyond rote memorization, reduced common misconceptions through direct experience, and enhanced long-term retention of scientific knowledge. Students' testimonies revealed that personally conducting investigations made abstract concepts tangible and memorable, exemplified by one student's reflection on understanding photosynthesis through direct manipulation of

plant materials rather than merely reading about the process. Teachers corroborated this finding, noting qualitative differences in how students could articulate and apply scientific concepts following inquiry-based instruction.

Increased motivation and interest was prominently featured in 87% of student responses and 83% of teacher responses, manifesting as greater curiosity about scientific phenomena, genuine enjoyment of science lessons, voluntary participation even among typically disengaged students, and emerging aspirations for science-related careers, which aligned closely with the quantitative improvements in emotional engagement (d = 1.49). However, the qualitative data also illuminated significant implementation challenges that all teachers (100%) and 42% of students identified, including large class sizes that complicated group management and equitable participation, insufficient laboratory materials that prevented simultaneous hands-on experiences for all students, time constraints imposed by extensive syllabi and examination pressures, and inadequate physical spaces for conducting inquiry activities. Teachers expressed particular frustration with tensions between their pedagogical commitment to inquiry-based learning and institutional pressures to cover content rapidly to prepare students for standardized examinations, a contextual reality unique to resource-constrained educational systems. These challenges provided important nuance to the quantitative regression findings showing that class size negatively predicted engagement and that laboratory resources positively predicted engagement, revealing the mechanisms through which these structural factors operated. The development of scientific skills theme, recognized by 73% of students and 96% of teachers, highlighted cognitive benefits including critical thinking, problem-solving abilities, data analysis skills, and scientific reasoning that traditional approaches rarely cultivated. Enhanced social skills and shifts in teacher-student dynamics, reported by substantial proportions of participants, revealed additional benefits of IBL beyond traditional engagement and achievement metrics, including improved peer collaboration, communication abilities, teacher facilitation roles, and student autonomy. Collectively, these qualitative findings provided depth, context, and explanatory power to the quantitative results, revealing not only that inquiry-based learning significantly improved student engagement in Ugandan secondary science classrooms but also illuminating how and why these improvements occurred, what benefits extended beyond measurable engagement, and what contextual challenges required attention for successful scaling and sustainability of IBL approaches in resource-constrained educational settings.

Conclusion

This mixed-methods study conclusively demonstrated that inquiry-based learning had a significant and substantial positive impact on student engagement in science classrooms across Ugandan secondary schools, fulfilling all three specific objectives of the research. Addressing the first objective, the quantitative findings revealed that inquiry-based learning significantly enhanced cognitive, behavioral, and emotional engagement levels of secondary school students compared to traditional teaching methods, with very large effect sizes (Cohen's d ranging from 1.49 to 1.84) indicating profound practical significance that persisted even after controlling for baseline engagement, prior science achievement, and socioeconomic status through ANCOVA analyses. The intervention group demonstrated mean improvements of 0.94 points in cognitive engagement, 1.25 points in behavioral engagement, and 1.07 points in emotional engagement on a five-point scale, while the control group showed negligible changes, providing robust empirical evidence that IBL was substantially more effective than traditional teacher-centered approaches in promoting multidimensional student engagement. Regarding the second objective, the qualitative analysis revealed that teachers perceived inquiry-based learning as transformative for student learning, recognizing enhanced active participation, improved conceptual understanding, and development of scientific skills among their students; however, teachers also identified significant implementation challenges including large class sizes, insufficient laboratory materials and resources, time constraints imposed by extensive syllabi, and persistent examination pressures that created tensions between pedagogical ideals and institutional realities in resource-constrained Ugandan schools. The regression analysis further illuminated that teacher experience with IBL and laboratory resources availability were significant positive predictors of engagement outcomes, while class size negatively predicted engagement, underscoring the contextual factors that facilitated or hindered effective IBL implementation. Addressing the third objective, students' perspectives revealed overwhelmingly positive perceptions of how inquiry-based learning influenced their motivation, participation, and interest in science learning, with 87-89% of students reporting increased motivation, active participation, and enjoyment of science, alongside testimonies describing transformative experiences of conducting authentic investigations, developing scientific reasoning skills, and connecting abstract concepts to tangible real-world phenomena. Students particularly valued the shift from passive reception of information to active construction of knowledge through hands-on experimentation and collaborative group work, though some acknowledged challenges related to large group sizes and limited materials that occasionally constrained equitable participation. The convergence of quantitative and qualitative findings provided comprehensive, contextualized evidence that inquiry-based learning represented an effective pedagogical approach for enhancing student engagement in Ugandan secondary science education, addressing long-standing challenges of passive learning and poor outcomes, while simultaneously revealing critical implementation considerations regarding resources, teacher professional development, class sizes, and examination-oriented educational cultures that required systemic attention for successful scaling and sustainability of learner-centered approaches across Uganda's diverse secondary school landscape.

Recommendations

Systematic Integration of IBL into Science Curriculum with Adequate Resource Allocation: The Ministry of Education and Sports should mandate the integration of inquiry-based learning approaches into the national science curriculum for secondary schools, accompanied by substantial investment in laboratory infrastructure, scientific apparatus, and consumable materials to ensure

that all schools possess the minimum resources necessary for effective IBL implementation. This recommendation should include the development of contextualized IBL lesson exemplars aligned with the existing syllabus, establishment of regional science resource centers where schools can borrow equipment, and partnerships with universities and non-governmental organizations to supplement resource gaps, particularly in rural and under-resourced schools, thereby addressing the critical resource constraints that teachers identified as primary implementation barriers.

Comprehensive and Sustained Teacher Professional Development Programs: Educational authorities should establish mandatory, sustained professional development programs for science teachers that extend beyond one-time workshops to include ongoing mentorship, peer learning communities, and classroom-based coaching in inquiry-based pedagogies. These programs should specifically address practical implementation strategies for managing inquiry activities in large classes, facilitating student-centered discussions, designing context-appropriate investigations with limited resources, balancing inquiry approaches with examination preparation requirements, and transitioning from traditional teacher-centered to facilitative roles, while providing teachers with opportunities to practice, reflect, and refine their IBL instructional skills over multiple terms.

Examination Reform to Align Assessment with Inquiry-Based Learning Outcomes: The Uganda National Examinations Board should progressively reform science examinations to include assessment items that evaluate scientific inquiry skills, critical thinking, problem-solving abilities, and application of knowledge to novel contexts, rather than predominantly testing factual recall and procedural memorization. This reform should incorporate practical examinations that assess students' abilities to design investigations, collect and analyze data, draw evidence-based conclusions, and communicate scientific findings, thereby creating systemic alignment between progressive pedagogical approaches and high-stakes assessments that currently incentivize traditional teaching methods focused on content coverage and memorization.

References.

Alamri, M. M. (2019). Students' academic achievement performance and satisfaction in a flipped classroom in Saudi Arabia. *International Journal of Technology Enhanced Learning*, *11*(1). https://doi.org/10.1504/IJTEL.2019.096786

Dr. Ariyo Gracious Kazaara, & Musiimenta Nancy. (2025). Lazy at Work, Lazy at Home: An Examination of Behavioral Consistency in Conscientiousness Across Life Domains. *International Journal of Academic and Applied Research*, *9*(11), 310–317.

Gracious Kazaara, A., & Julius, A. (2025). Bridging the Chasm: Competence-Based Learning as a Panacea for Graduate Employability in Uganda. In *International Journal of Academic and Applied Research* (Vol. 9). www.ijeais.org/ijaar

Gracious Kazaara, A., & Kazaara, A. I. (2025). Equality Versus Equity in Ugandan Policy: A Critical Analysis of Conceptual Approaches and Development Outcomes. In *International Journal of Academic and Applied Research* (Vol. 9). www.ijeais.org/ijaar

Julius, A., & Gracious Kazaara, A. (2025). Age and Culture as Correlates of Learner Discipline in Higher Institutions of Learning in Uganda. In *International Journal of Academic Pedagogical Research (IJAPR)* (Vol. 9). www.ijeais.org/ijapr

Julius, A., & Isaac Kazaara, A. (2025a). Survival and Resilience: An Analysis of Livelihood Strategies Among Uganda's Unemployed Youth. In *International Journal of Academic and Applied Research* (Vol. 9). www.ijeais.org/ijaar

Julius, A., & Isaac Kazaara, A. (2025b). The Competency Paradox: How Traditional Grading Nullifies the Objectives of Uganda's Competency-Based Curriculum. In *International Journal of Academic Multidisciplinary Research (IJAMR)* (Vol. 9). www.ijeais.org/ijamr

Julius, A., & Kazaara, A. I. (2025). The Adoption-Adaptation Imperative: An Economic Argument for Leveraging Exogenous Innovation in Africa. *International Journal of Academic and Applied Research*. www.ijeais.org/ijaar

Julius, A., & Mategeko, B. (2025a). Failing the Test: Rethinking "Failure" for Students Scoring Subsidiaries in Uganda's High-Stakes Grading System. In *Avance International Journal of Academic and Applied Research* (Vol. 1). https://journals.aviu.ac.ug

Julius, A., & Mategeko, B. (2025b). Failing the Test: Rethinking "Failure" for Students Scoring Subsidiaries in Uganda's High-Stakes Grading System. In *Avance International Journal of Academic and Applied Research* (Vol. 1). https://journals.aviu.ac.ug

Julius, A., & Nalukwago, H. (2025a). Beyond Binary: Evaluating the Merits of Maintaining Differentiated Grading in Uganda's Education System. In *Avance International Journal of Academic and Applied Research* (Vol. 1). https://journals.aviu.ac.ug

Julius, A., & Nalukwago, H. (2025b). Beyond Binary: Evaluating the Merits of Maintaining Differentiated Grading in Uganda's Education System. In *Avance International Journal of Academic and Applied Research* (Vol. 1). https://journals.aviu.ac.ug

Julius, A., & Nancy, M. (2025). Bridging the Chasm: An Evaluation of the Transition from Secondary Education to Higher Learning in Uganda: A Case. In *International Journal of Academic and Applied Research* (Vol. 9). www.ijeais.org/ijaar

Julius, A., & Sula, N. (2025). The Double-Edged Sword: Class Monitors and Prefects in Enhancing Discipline within Ugandan Schools. In *Avance International Journal of Academic and Applied Research* (Vol. 1). https://journals.aviu.ac.ug

Kazaara, A. I., & Audrey, A. (2025). Gender and Infidelity Patterns: A Cross-Cultural Analysis with Focus on Uganda. In *International Journal of Academic Management Science Research*. www.ijeais.org/ijamsr

Mathias, A., Affiong Mathias, A., & Blessing, N. (2022). Psychosocial determinant of teenage pregnancy among selected secondary school students in akamkpa local government area, cross river state, nigeria. *Global Journal of Pure and Applied Sciences*, *28*(1). https://doi.org/10.4314/gjpas.v28i1.7

Nelson, K., Christopher, F., & Milton, N. (2022). *Teach Yourself Spss and Stata*. *6*(7), 84–122.

Nelson, K., Kazaara, A. G., & Kazaara, A. I. (2023). *Teach Yourself E-Views*. *7*(3), 124–145.

Okech, J. B., Yuwono, I., & Abdu, W. J. (2021). Implementation of inclusive education practices for children with disabilities and other special needs in Uganda. In *Journal of Education and e-Learning Research* (Vol. 8, Issue 1). https://doi.org/10.20448/journal.509.2021.81.97.102

Sinha, M., Shekhar, & Valeri, M. (2024). How does entrepreneurship education promote creativity and innovation? *International Journal of Technology Enhanced Learning*, *16*(1). https://doi.org/10.1504/IJTEL.2024.135431

Wahjusaputri, S., Nastiti, T. I., & Liu, Y. (2024). Development of a hybrid teaching factory model based on school governance in improving employability skills of vocational students. *Jurnal Pendidikan Vokasi*, *14*(1). https://doi.org/10.21831/jpv.v14i1.65108

Wang, J., & Zhan, Q. (2021). Visualization Analysis of Artificial Intelligence Technology in Higher Education Based on SSCI and SCI Journals from 2009 to 2019. *International Journal of Emerging Technologies in Learning*, *16*(8). https://doi.org/10.3991/ijet.v16i08.18447

Wilson, R., Joiner, K., & Abbasi, A. (2021). Improving students' performance with time management skills. *Journal of University Teaching and Learning Practice*, *18*(4). https://doi.org/10.53761/1.18.4.16

Yang, Y., Zhu, G., & Chan, C. K. K. (2022). Evolution of the academic emotions of academically low-achieving students in knowledge building. *International Journal of Computer-Supported Collaborative Learning*, *17*(4). https://doi.org/10.1007/s11412-022-09380-y

Yusra, W. E., & Silvianetri, S. (2022). Implementation of Guidance And Counseling Services By Primary School Teachers. *Journal of Islamic Education Students (JIES)*, *2*(1). https://doi.org/10.31958/jies.v2i1.5591