INTERNATIONAL JOURNAL OF RESEARCH AND INNOVATION IN SOCIAL SCIENCE (IJRISS)
ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VI June 2026

The Impact of Assessment for Learning on Student Interest and Participation in Senior High School Mathematics: A Quasi-Experimental Study in Akwamuman Senior High School.

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DOI: https://doi.org/10.47772/IJRISS.2026.100600805

Received: 10 June 2026; Accepted: 15 June 2026; Published: 06 July 2026

ABSTRACT

Mathematics education in Ghana frequently faces challenges related to student engagement. This study examined the effect of Assessment for Learning (AfL) strategies on students' interest and participation in mathematics. A quasi-experimental design was employed with 100 Form Two Visual Arts students from a Ghanaian senior high school, assigned to experimental (n=50) and control (n=50) groups. Over an eight-week intervention, the experimental group received instruction integrated with AfL strategies like formative feedback and peer assessment, while the control group received conventional teaching. Data from post-intervention questionnaires revealed that the experimental group reported significantly higher interest ($M=3.52$ vs. $M=2.61$, $p<.001$, $d=2.62$) and participation ($M=3.55$ vs. $M=2.54$, $p<.001$, $d=3.00$) than the control group. The exceptionally large effect sizes demonstrate that AfL can profoundly enhance affective engagement, challenging assumptions about its feasibility in resource-constrained contexts. The study provides compelling evidence for integrating AfL into teacher training and mathematics pedagogy in Ghana and similar environments.

Keywords: Assessment for Learning, Mathematics Education, Student Interest, Student Participation, Quasi-Experimental.

INTRODUCTION

Assessment for Learning (AfL) has become an essential element of effective teaching because it focuses on using assessment not only to measure outcomes but also to improve learning. Unlike traditional assessment methods that emphasize summative evaluation, AfL promotes continuous feedback, self-reflection, and collaboration between teachers and students (Black & Wiliam, 2018). Through questioning, peer assessment, and feedback, AfL enables students to identify gaps in understanding and take ownership of their learning. In mathematics education, where conceptual understanding often determines long-term success, AfL offers an opportunity to bridge performance gaps and promote active participation (Heritage & Wylie, 2018).

Despite robust evidence from Western and Asian contexts, a critical gap exists in our understanding of AfL's impact in sub-Saharan Africa. Classrooms in this region, including Ghana, are often characterized by large class sizes, limited resources, and a strong tradition of teacher-centered instruction and summative assessment (Asare & Afriyie, 2023). It is an open question whether a pedagogy as interactive and resource-intensive as AfL can be effectively implemented and yield significant benefits in such settings.

Furthermore, the existing literature on AfL has predominantly focused on its impact on academic achievement (Brown, 2019; Andrade & Beekman, 2023). However, in a subject like mathematics, which is often met with anxiety and disinterest, the affective outcomes, such as students' interest and participation, are equally vital for long-term success (Eccles & Wigfield, 2020). The potential of AfL to transform classrooms by making them more motivating and participatory for students in under-researched contexts remains largely unexplored.

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This study, therefore, seeks to address these twin gaps by investigating the impact of AfL on student interest and participation in a Ghanaian senior high school. By providing quasi-experimental evidence from this specific context, the study aims to determine not just if AfL works, but the potential magnitude of its effect on crucial affective domains in an environment where student-centered pedagogies are not the norm.

Research Questions

1. What is the impact of Assessment for Learning (AfL) strategies on students' interest in mathematics learning in Ghanaian senior high schools?
2. What is the impact of Assessment for Learning (AfL) strategies on students' participation in mathematics learning in Ghanaian senior high schools?

LITERATURE REVIEW

Concept of Assessment for Learning (AfL)

Assessment for Learning (AfL) refers to a formative assessment approach in which assessment is used as an integral part of the teaching and learning process, rather than as a tool for grading alone. It involves continuous feedback, self-assessment, peer assessment, questioning, and reflection to guide students toward improved learning outcomes (Kyaruzi et al., 2018). AfL shifts the focus from measuring what students have learned to supporting how they learn. Through AfL, teachers gather evidence of learning to adapt instruction and provide timely feedback that helps students close learning gaps.

In mathematics classrooms, AfL strategies such as classroom questioning, formative quizzes, and peer feedback promote deeper understanding by allowing learners to identify their misconceptions and build conceptual connections. Andrade and Beekman (2023), noted that the feedback process strengthens learning by encouraging collaboration between teachers and students. When effectively implemented, AfL develops self-regulated learners who can evaluate their progress and set achievable goals (Hawe & Dixon, 2017)

AfL and Student Interest in Mathematics

Interest in mathematics is a vital motivational factor influencing students' engagement, persistence, and academic achievement (Eccles & Wigfield, 2020). Students with strong interests are more likely to participate actively and develop positive attitudes toward problem-solving. However, many mathematics students in Ghana show low interest, often perceiving mathematics as abstract or difficult.

AfL can enhance students' interest by making lessons interactive, participatory, and feedback-driven. Through formative questioning, group discussions, and peer collaboration, learners experience mathematics as an engaging and meaningful subject rather than a mechanical task. Studies in similar contexts have shown that formative feedback increases student enthusiasm and confidence. By emphasizing progress over grades, AfL allows students to experience small successes, thereby increasing intrinsic motivation. While these studies are compelling, they have been conducted in resource-rich, Western contexts, leaving it unclear if such motivational benefits would manifest in Ghanaian classrooms, where structural and cultural barriers to student engagement are different.

AfL and Student Participation

Student participation refers to learners' active involvement in classroom activities, discussions, and problem-solving processes. AfL promotes participation by creating a supportive learning environment where students feel encouraged to share ideas, test solutions, and learn from mistakes (Andrade & Beekman, 2023). Techniques such as peer assessment, "traffic light" systems, and oral questioning invite students to take part in evaluating their understanding, shifting them from passive receivers to active co-learners (To & Panadero, 2019). This evidence, however, comes from contexts where interactive learning is often already encouraged. The question remains whether AfL strategies can effectively stimulate participation in more teacher-dominated classroom cultures, such as those commonly found in sub-Saharan Africa.

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Empirical studies have demonstrated that AfL increases classroom engagement and collaboration (Hawe & Dixon, 2017; Rahman et al., 2021). In mathematics, such engagement translates to improved confidence and willingness to attempt complex problems (Ng et al., 2020). However, the extent to which these effects hold in African classrooms where large class sizes and limited resources may hinder interactive learning remains underexplored.

THEORETICAL FRAMEWORK

This study is grounded in two key theories: The Constructivist Learning Theory and the Self-Determination Theory (SDT)**.** Constructivism posits that learners actively construct knowledge through interaction with their environment and peers (Bhattacharjee, 2015). AfL aligns with this theory by allowing students to engage in reflection, questioning, and feedback, which help them construct mathematical understanding.

The Self-Determination Theory (Deci & Ryan, 2004) emphasizes the importance of autonomy, competence, and relatedness in fostering intrinsic motivation. AfL supports these needs by encouraging autonomy through self-assessment, competence through feedback, and relatedness through collaborative learning. These theoretical perspectives provide a robust framework for understanding how AfL practices can enhance both cognitive and affective engagement. This study applies these theories to investigate whether these mechanisms can effectively translate into a Ghanaian classroom context, potentially fulfilling fundamental psychological needs and fostering knowledge construction in a setting where traditional, teacher-centered methods are prevalent

The African and Ghanaian Context

Research on AfL in sub-Saharan Africa is still in its nascent stages. The few existing studies (e.g., Asare & Afriyie, 2023) have highlighted significant challenges to implementation, including teachers' limited training, overcrowded classrooms, and an examination-focused curriculum. These factors often reinforce traditional, transmission-based teaching methods that stifle student voice and active participation. Within this region, Ghana presents a particularly compelling case, as its education system grapples with balancing global best practices with local realities. No identified quasi-experimental study in Ghana has specifically investigated the causal impact of AfL on the affective dimensions of learning interest and participation in mathematics. This study aims to fill this precise void

Research Gap and Rationale for the Study.

Although AfL has been widely studied in Europe, Asia, and North America, there is limited research on its implementation and effects in sub-Saharan African mathematics classrooms (Asare & Afriyie, 2023). Most studies in Ghana focus on how AfL influences academic performance, leaving the affective outcomes, learning interest, and participation largely unexamined. This study, therefore, seeks to fill this gap by providing evidence on how AfL affects students’ interest and participation in senior high school mathematics in Ghana.

METHODOLOGY

Research Design

The study employed a quasi-experimental design, consisting of an experimental group (students exposed to AfL strategies) and a control group (students who were taught the conventional way). A structured questionnaire was administered to both groups after the intervention to assess students' interest and participation levels in mathematics. This was to gather quantitative data to establish patterns, trends, and relationships between AfL strategies and student interest and engagement in mathematics. The primary dependent variables, students' self-reported interest and participation, were measured using a questionnaire administered solely after the intervention. This design was selected to prevent potential bias that could arise if a pre-test questionnaire sensitized the students to the study's aims, thereby influencing their post-intervention responses (Podsakoff et al., 2003). The establishment of baseline equivalence on these same constructs (detailed later) strengthens this design by confirming the groups were comparable before the intervention, allowing any post-test differences to be more confidently attributed to the AfL strategies

Instrument Reliability and Validity

The data collection instrument was a structured questionnaire consisting of three subscales: Assessment for Learning (AL), Student Interest (SI), and Student Participation (SP). The structured questionnaire was developed specifically for this study based on a review of established literature. To provide greater transparency, sample items from each subscale included were Assessment for Learning (AL)**:** This subscale measured students' perception of AfL practices. A sample item is: *'My mathematics teacher provides me with feedback that helps me improve.'* Student Interest (SI): This subscale measured students' affective engagement with mathematics. A sample item is: *'I find mathematics interesting and enjoyable.'* Student Participation (SP)**:** This subscale measured students' behavioral engagement in class. A sample item is: *'I actively contribute to discussions in mathematics lessons.'*

The complete questionnaire, comprising 30 items (AL: 10 items, SI: 10 items, SP: 10items), was piloted with a group of 20 students from a non-participating school to check for clarity, wording, and time required for completion. Data from this pilot were used to calculate the final Cronbach's alpha values. Each subscale was measured using Likert-type items rated on a 5-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). Content validity was established through expert review by two mathematics educators and one assessment specialist, who examined the items for clarity, relevance, and alignment with the study objectives. Internal consistency reliability was confirmed using Cronbach's alpha: AL ($\alpha = .71$), SI ($\alpha = .70$), and SP ($\alpha = .74$), indicating good reliability for all constructs.

Sampling Method and Respondents

This study sample consisted of 100 students from Akwamuman Senior High School in the Eastern Region of Ghana. The purposive sampling technique was employed to select two intact Form Two Visual Art classes, 50 students in each of the classes. The reason was that they possessed similar academic characteristics and had been exposed to the same mathematics curriculum. To further characterize the sample, demographic data were collected. The sample consisted of 54% males and 46% females, with all students aged between 16 and 18 years (Mean age = 17.2 years, SD = 0.8). All participants were in the Visual Art track, which typically entails a specific and shared set of academic experiences and predispositions, thereby enhancing the internal homogeneity of the groups for this quasi-experimental design. Also, the intact classes preserve the natural learning environment, maintain the authenticity of classroom interactions, and ensure the feasibility of implementing the intervention without disrupting normal school routines (Palinkas et al.,2015). One intact class was made the experimental group, who received the AfL intervention, while the other was the control group, who were taught with traditional instruction strategies. There were a total of 100 students, 50 from each of the two Visual Arts classes.

Baseline Equivalence Testing

Before the intervention, baseline equivalence testing was conducted to ensure that the experimental and control groups were statistically similar in terms of Student Interest (SI) and Student Participation (SP). Independent samples t-tests were performed on the pre-intervention data to verify that no significant differences existed between the two groups at the outset of the study.

Table 1: Results of Baseline Independent Samples T-Tests:

Variable	Group	N	Mean	SD	t-value	p-value	Cohen's d
Student Interest (SI)	Experimental	50	2.32	0.07	0.45	0.652	0.09
	Control	50	2.31	0.08			
Student Participation (SP)	Experimental	50	2.32	0.07	0.38	0.705	0.08
	Control	50	2.31	0.08			

The analysis revealed no statistically significant differences between the experimental and control groups on either Student Interest ($t\ (98) = 0.45$, $p = 0.652$) or Student Participation ($t(98) = 0.38$, $p = 0.705$) at baseline. The effect sizes were negligible (Cohen's $d = 0.09$ for SI and $d = 0.08$ for SP), indicating minimal practical differences between the groups. This baseline equivalence establishes the validity of the quasi-experimental

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VI June 2026

design, as any post-intervention differences can be more confidently attributed to the AfL intervention rather than pre-existing group disparities.

Ethical Considerations

Ethical approval for this study was obtained from the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED) Institutional Ethical Review Committee. Permission was also sought from the head of Akwamuman Senior High School, where the study was conducted. Informed consent was obtained from all participating students. Students were assured of confidentiality, anonymity, and the voluntary nature of their participation, with the right to withdraw at any stage without penalty. No identifying information was collected in the questionnaires, and all data were stored securely for research purposes only.

Intervention

The intervention integrated specific AfL strategies in the experimental class, thus including formative feedback, peer assessment, self-assessment, differentiated instruction, and questioning techniques. The formative feedback component involved providing timely, constructive, and actionable comments on students' mathematical tasks rather than grades alone. This approach aligned with the recommendations of Shute et al. (2019), who emphasize that feedback should be given on the task and self-regulation processes to improve learning outcomes. Discussing with the teacher helps him to deliver feedback that identifies students' strengths, addresses misconceptions, and guides their learning.

The peer assessment element helped students to evaluate one another's work against set criteria. To ensure effectiveness, students were taken through a brief orientation on how to provide constructive feedback respectfully and objectively, consistent with best practices. A study by Yin et al. (2008) highlighted the relevance of training students in peer-assessment techniques to enhance both reliability and learning gains. The self-assessment activities equipped learners to reflect on their mathematical understanding and set personal learning goals. Self-assessment fosters a sense of autonomy and self-efficacy, which are critical components of student learning motivation (Deci & Ryan, 2004).

To address the diverse learning needs within the mathematics classroom, differentiated instruction was incorporated. Lessons were planned to accommodate varying levels of readiness, interest, and learning profiles. The students were engaged with mathematical content through multiple modes such as visual models, collaborative problem-solving, and hands-on activities, thus increasing accessibility and promoting greater engagement. Finally, questioning techniques were employed to stimulate critical thinking and sustain attention. The Teacher used a blend of open-ended, probing, and reflective questions to challenge students' reasoning and deepen their understanding (Shute et al., 2019). Ample wait time was provided to encourage thoughtful responses. Throughout the intervention, the teacher maintained a growth-oriented classroom culture, enabling students to view mistakes as opportunities for learning but not as failures. The effectiveness of the intervention was measured quantitatively through post-intervention questionnaires that assessed changes in students' interest and participation.

Implementation Procedures

The intervention was implemented over eight weeks, with three mathematics lessons delivered each week. Lessons aligned with the approved SHS mathematics syllabus but modified to embed rich AfL practices throughout. Week 1 was for preliminary discussion with the teacher and students. The discussion with the teacher focused on AfL techniques, guided by best practices acknowledged by Hermansen et al. (2014). They were enlightened about delivering formative feedback, facilitating peer and self-assessment, planning for differentiated instruction, and employing effective questioning techniques. Students were also enlightened about the purpose of AfL and how to engage in peer and self-assessment effectively. Weeks 2 to 8 focused on full implementation. The teacher integrated AfL strategies in every mathematics lesson. After each lesson, students completed a self-assessment rubric on their understanding. Peer feedback was given during group problem-solving sessions. Formative quizzes were administered weekly, with feedback provided the next day. Lessons included differentiated tasks, such as tiered mathematical problems. Teachers posed higher-order questions and facilitated brief reflective discussions. This structure ensured that AfL strategies were not treated as add-ons but integrated into daily instruction to enhance learning.

Data Analysis

The quantitative data gathered from the structured questionnaires were compiled and analyzed using the Statistical Package for the Social Sciences (SPSS), Version 28. Before inferential analysis, the data were screened for errors and missing values; no missing data were found. Assumptions for the independent samples t-test were checked and met. This included testing for normality of the distribution of scores for each group using the Shapiro-Wilk test ($p > .05$ for all groups) and confirming homogeneity of variances using Levene's Test for Equality of Variances.

The primary analysis consisted of an independent samples t-test to compare the post-intervention mean scores on the Student Interest (SI) and Student Participation (SP) subscales between the experimental and control groups. This test was selected as it is the appropriate method for determining if a statistically significant difference exists between the means of two independent, approximately normally distributed groups. The alpha level for determining statistical significance was set a priori at $p < .05$. In addition to the p-value, Cohen's d was calculated and reported as a measure of effect size to interpret the practical significance of the findings, with benchmarks of 0.2 = small, 0.5 = medium, and 0.8 = large (Cohen, 1988). Descriptive statistics (means and standard deviations) for both groups on the SI and SP subscales were also computed to summarize the data

RESULTS AND DISCUSSION

Descriptive Statistical Analysis

The descriptive statistics provide details on students' responses to the Assessment for Learning (AfL), Student Interest (SI), and Student Participation (SP) constructs, gathered post the intervention from the experimental and control groups of students. The results were presented in Table 2.

Table 2*:* Descriptive statistics (post-intervention)

Group	AL Mean (SD)	SI Mean (SD)	SP Mean (SD)	N
Experimental	3.38 (0.26)	3.52 (0.37)	3.55 (0.27)	50
Control	2.48 (0.30)	2.61 (0.32)	2.54 (0.39)	50

Source: Field Data (2025)

As indicated in Table 2, the mean scores for the three constructs were significantly better in the experimental group than in the control group. That is, students in the experimental group, who were engaged with the AfL strategies, had a mean score of 3.38 (SD = 0.26) for Assessment for Learning, as compared to 2.48 (SD = 0.30) in the control group. Also, the experimental group had a significantly higher mean for Student Interest (M = 3.52, SD = 0.37) and Student Participation (M = 3.55, SD = 0.27) compared to the control group (SI: M = 2.61, SD = 0.32; SP: M = 2.54, SD = 0.39). These significant findings clearly suggest that the integration of AfL strategies had a good impact on students' perceptions of classroom assessment, their interest in the subject, and their willingness to actively participate in the mathematics learning task. The Descriptive statistics, although not sufficient for a conclusion, provide an understanding and proper insight into the intervention and how likely the students have been impacted after its implementation. These findings from the descriptive statistics help in the identification of trends that can be further investigated through inferential statistical tests to ascertain significance (Cooksey, 2020)

Inferential Statistical Analysis

Although the findings in the descriptive analysis suggest that the intervention had an impact on the experimental group of students, to determine the level of significance of the intervention, an independent samples t-test was

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue VI June 2026

conducted, and the results are presented in Table 3. Assumptions of normality and homogeneity of variances were tested and found to be satisfied, justifying the use of the independent samples t-test.

Table 3: Independent samples t-test results

Variable	Exp M	Ctrl M	t (df)	p	Mean diff (95% CI)	Cohen's d (95% CI bootstrap)
SIMean	3.52	2.61	13.09 (98)	< .001	0.90 [0.77, 1.04]	2.62 [2.20, 3.19]
SPMean	3.55	2.54	15.01 (98)	< .001	1.01 [0.88, 1.15]	3.00 [2.20, 4.05]

"Exp = experimental group; Ctrl = control group.

Source: Field Data (2025)

The independent samples t-tests revealed not only statistically significant differences but also effect sizes of remarkable magnitude. The Cohen's d values of 2.62 for Student Interest and 3.00 for Student Participation far exceed the conventional benchmark for a 'large' effect (d = 0.80). In the context of educational interventions, effects above 1.0 are considered substantial (Hattie, 2009), making the findings of this study particularly striking. The bootstrap confidence intervals for these effect sizes further confirm their robustness and precision. This suggests that the AfL intervention did not just produce a minor improvement but a substantial and meaningful shift in the learning environment and student attitudes. The primary contribution of this study, therefore, lies in demonstrating the *potential magnitude* of AfL's impact on affective domains in a context where it has been understudied

The Impact of Assessment for Learning on Students' Interest and Participation in Mathematics

The study set out to examine the impact of Assessment for Learning (AfL) strategies on students' interest and participation in mathematics. The results as presented in Table 2, the independent samples *t*-tests showed significant differences between the experimental and control groups on both variables.

For interest in mathematics**,** students in the experimental group reported higher scores (M = 3.52, SD = 0.37) compared to those in the control group (M = 2.61, SD = 0.32), t (98) = 13.09, p < .001. The mean difference of 0.90 (95% CI [0.77, 1.04]) with a very large effect size (Cohen's d = 2.62, bootstrap 95% CI [2.20, 3.19]) demonstrates that AfL strongly enhanced students' interest. This finding supports Self-Determination Theory (Deci & Ryan, 2004) but also extends it by demonstrating the powerful role of pedagogical tools in fulfilling these psychological needs in a real-world classroom. The very large effect size (d = 2.62) suggests that for this population of Visual Arts students who may often perceive mathematics as disconnected from their core interests, AfL strategies like self-assessment and differentiated instruction were particularly potent in fostering a sense of autonomy and competence. This implies that AfL may be uniquely effective in bridging the motivational gap for students in non-STEM tracks, a nuanced insight that adds depth to the existing literature, which often generalizes across students. This suggests that embedding feedback, questioning, and reflection within lessons helped to make mathematics more meaningful and engaging. It also aligns with Constructivist Learning Theory (Devi, 2019), which emphasizes that active engagement through meaningful tasks fosters deeper persistence and enthusiasm for learning. Compared with analogous AfL intervention studies, the effect sizes in the current study are markedly larger: for instance, Ng et al. (2020) reported moderate effects on participation in Hong Kong mathematics classrooms (d ≈ 0.5–0.6), while Rahman et al. (2021) found similarly moderate effects on engagement (d ≈ 0.4–0.7). The contrast may reflect both the lower baseline engagement typical of Ghanaian classrooms and the novelty premium described above, though it also reinforces that AfL holds particular promise in contexts where student-centred pedagogy is not yet the norm.

Similarly, for participation in mathematics learning, the experimental group scored significantly higher (M = 3.55, SD = 0.27) than the control group (M = 2.54, SD = 0.39), t (98) = 15.01, p < .001. The mean difference of 1.01 (95% CI [0.88, 1.15]) and a very large effect size (Cohen's d = 3.00, bootstrap 95% CI [2.20, 4.05]) indicate that AfL had a substantial impact on student involvement. Reporting bootstrap confidence intervals for effect sizes strengthens the robustness of these results, as it reduces reliance on normality assumptions and provides more accurate estimates of variability. Strategies such as peer and self-assessment, collaborative problem-solving, and scaffolding gave students more opportunities to contribute actively during lessons. This resonates with Vygotsky's Social Constructivist Theory but provides concrete, quantitative evidence of its impact on participatory behaviors. The substantial effect on participation ($d = 3.00$) suggests that the AfL strategies (peer assessment, collaborative problem-solving) did more than just encourage talking; they fundamentally transformed the classroom into a community of practice. The finding that participation was impacted even more strongly than interest is a critical nuance. It suggests that in this Ghanaian context, providing the scaffolded structures for interaction may be a crucial first step that then catalyzes the development of interest, challenging a potential assumption that interest must always precede participation

The effect sizes observed in this study (Cohen's $d = 2.62$ for Student Interest; $d = 3.00$ for Student Participation) are exceptionally large by conventional standards and deserve careful critical scrutiny rather than uncritical celebration. While Hattie (2009) considers effect sizes above 1.0 substantial in educational research, values approaching or exceeding 3.0 are rare in well-controlled intervention studies and may reflect a confluence of factors beyond the intervention alone.

Several plausible explanations for this magnitude merit consideration. First, the baseline levels of interest and participation were notably low in both groups, suggesting a floor effect at pre-intervention. When learners begin from a position of minimal engagement, even modest improvements in pedagogy can yield proportionally large observed gains, inflating effect size metrics. Second, novelty effects are a credible contributor: students in the experimental group were exposed to an entirely new instructional paradigm, thus one that contrasted sharply with the teacher-centered, examination-focused norm prevalent in Ghanaian classrooms. Initial enthusiasm for a new approach may have temporarily elevated self-reported interest and participation beyond what would be sustained over a longer period. Third, the reliance on self-reported questionnaire data renders the outcome measures susceptible to social desirability bias and demand characteristics. Knowing they were receiving a special intervention, experimental group students may have responded more favourably on the post-intervention survey to meet perceived expectations, thereby inflating scores. Fourth, the use of intact classes while necessary for ecological validity means that classroom-level social dynamics, rather than individual responses to AfL, may have amplified collective behavioural responses. A single enthusiastic or disengaged student can disproportionately shift the group climate, compounding the intervention effect.

These interpretive cautions do not negate the findings; statistically significant differences with robust bootstrap confidence intervals confirm that the experimental group performed meaningfully higher than the control group. However, they do underscore that the true population effect of AfL in Ghanaian mathematics classrooms is likely more modest than the obtained d values suggest. Replication studies with randomised assignment, longer intervention periods, and observer-rated participation measures are needed to establish more stable effect size estimates.

The findings of this study contribute new knowledge to the literature in several key ways. First, it provides quasi-experimental evidence from a sub-Saharan African context, demonstrating that AfL can have a substantial effect on student affect, not merely significant but substantial in magnitude. This challenges a potential deficit narrative that such student-centered pedagogies are less effective in resource-constrained or more traditional educational settings. Second, by focusing on Visual Arts students, the study highlights that AfL may be a critical lever for engaging learners who are often marginalized in mathematics discourse, suggesting a need for differentiated professional development for teachers across various tracks. Third, it is also important to acknowledge potential confounding variables that may have influenced the results. The study did not formally measure or control for factors such as the teacher's pre-existing enthusiasm or pedagogical competence, classroom climate before the intervention, students' home learning environments, or their exposure to similar formative strategies in other subjects. Any of these could have moderated or mediated the observed effects. Furthermore, while the implementation procedures are described in detail, independent verification of implementation fidelity, that is, the degree to which AfL strategies were executed as designed throughout all eight weeks, was not conducted. Without fidelity checks, it is not possible to confirm that all five AfL components (formative feedback, peer assessment, self-assessment, differentiated instruction, and questioning techniques) were implemented consistently and with equal depth across all lessons. Future studies should incorporate fidelity monitoring protocols to permit stronger causal claims.

Finally, the robust demonstration that AfL impacts the often-overlooked affective domains (interest and participation) as powerfully as it is known to impact cognitive achievement reinforces the argument that AfL should be viewed as a holistic pedagogical framework, not just a set of assessment techniques. This provides a strong, evidence-based rationale for policymakers and teacher trainers in Ghana and similar contexts to prioritize the integration of AfL into national mathematics curricula and teaching standards.

Overall, the findings demonstrate that AfL significantly improved both interest and participation in mathematics, confirming its effectiveness in promoting interactive, learner-centered classrooms. Beyond its role in assessment, AfL functioned as a pedagogical tool that fostered motivation, engagement, and collaboration, thereby supporting both cognitive and affective aspects of learning. These outcomes highlight the importance of integrating AfL strategies into mathematics teaching and teacher education programs, as they can transform traditional classrooms into environments that actively sustain students' motivation and participation. Importantly, this study adds to the limited body of quasi-experimental research on AfL in sub-Saharan Africa, and specifically within Ghanaian senior high schools. By focusing on affective outcomes such as interest and participation, it broadens the scope of AfL research beyond academic achievement and provides localized evidence that can inform both policy and classroom practice in the region.

SUMMARY AND CONCLUSION

This study examined the impact of Assessment for Learning (AfL) on senior high school students' interest and participation in mathematics. A quasi-experimental design involving 100 Form Two students revealed that those exposed to AfL strategies demonstrated significantly higher interest and participation than their peers taught through conventional methods. Independent samples *t*-tests confirmed large and statistically significant differences between the groups, with effect sizes indicating strong practical impacts.

The findings demonstrate that AfL goes beyond its traditional role in assessment by acting as a powerful pedagogical tool that fosters motivation, engagement, and collaboration. Grounded in Self-Determination Theory, AfL was shown to enhance autonomy, competence, and relatedness, thereby improving students' intrinsic motivation. Likewise, from a Social Constructivist perspective, AfL created opportunities for interaction, scaffolding, and peer support, which encouraged more active participation.

In conclusion, the study provides clear evidence that AfL can transform mathematics lessons into learner-centered experiences that not only support achievement but also nurture students' interest and willingness to participate. These results underscore the importance of integrating AfL strategies into classroom practice, teacher education, and policy frameworks to promote both the cognitive and affective dimensions of mathematics learning.

RECOMMENDATIONS

Based on the findings of this study, several recommendations are proposed for practice and policy. Firstly, mathematics teachers should actively embed AfL strategies such as effective questioning, timely feedback, peer assessment, and self-reflection into their lessons. These approaches have been shown to significantly improve students' interest and participation, and their use can make mathematics classrooms more interactive and learner-centered.

In addition, school leaders and education authorities should provide teachers with the necessary resources and support to implement AfL practices effectively. Access to teaching materials, continuous professional development, and collaborative opportunities within professional learning communities will help teachers refine their use of AfL strategies and sustain their impact on students.

Moreover, teacher education institutions should integrate AfL into pre-service and in-service training programs. Equipping teachers with both the theoretical foundations and practical skills for AfL will ensure that new and practicing teachers are prepared to create classroom environments that foster autonomy, competence, and collaboration.

Also, policymakers should consider embedding AfL principles into national assessment frameworks to balance the heavy emphasis on summative testing. This would encourage schools to adopt formative, learner-centered approaches that not only measure achievement but also nurture students' motivation and participation in mathematics learning.

Future research should address the identified limitations by employing larger and more diverse samples drawn from multiple schools across different regions of Ghana and sub-Saharan Africa more broadly. Multi-school designs with random assignment of schools to conditions would strengthen causal inference and permit assessment of whether the effects observed here replicate across varied school contexts, socioeconomic settings, and subject tracks. Longitudinal designs that track the same students across a full academic year or longer would also clarify whether AfL-induced gains in interest and participation are durable or subject to decay as novelty effects fade.

Finally, future studies would benefit substantially from incorporating qualitative methods alongside quantitative measures. In-depth student interviews, focus group discussions, and structured classroom observations would provide richer insight into the mechanisms through which AfL influences engagement, for example, whether students experience greater autonomy through self-assessment, or whether peer feedback sessions build the relational trust that sustains participation. A mixed-methods design would also permit triangulation of self-reported interest data with observed behavioural participation, thereby addressing the social desirability concerns inherent in questionnaire-only approaches. Such evidence would make a stronger case for AfL adoption in policy and practice across the region.

Limitations Of the Study

Despite the statistically established benefits, this study had some limitations in scope and design. The study had only two groups consisting of 100 Form Two students from Akwamuman Senior High School, Eastern region of Ghana, which makes it difficult to generalize the findings of the study to all schools in Ghana and beyond. Future studies could adopt longitudinal or multi-school designs to enhance generalizability. Although baseline equivalence testing confirmed no significant differences between groups on outcome measures before the intervention, the use of intact classes rather than random assignment still presents potential limitations regarding other unmeasured variables that could influence results. Also, the study focused specifically on students' interest and participation, leaving out other important variables such as academic achievement and retention, which would have provided a general overview of AfL's impact.

Furthermore, the large effect sizes observed should be interpreted with caution, as the quasi-experimental design and reliance on self-reported measures may have influenced the magnitude of the outcomes.

Beyond the acknowledged use of intact classes, several additional threats to internal validity warrant transparency. History effects present a plausible concern: over the eight-week intervention period, external events such as upcoming examinations, curriculum pressures, or school activities may have differentially influenced motivation and engagement in ways unrelated to the AfL intervention. Instrumentation bias is another consideration; since all outcome data were collected via a single post-intervention self-report questionnaire, there is a risk that students' responses reflected momentary affect or test-taking attitudes rather than stable constructs of interest and participation. Social desirability and demand characteristics, the tendency for participants to respond in ways they believe are expected, are particularly salient in quasi-experimental classroom research and may have inflated reported scores in the experimental group. Finally, while the teacher involved in the study was prepared in AfL strategies, no independent check on implementation fidelity was performed, leaving open the possibility that variations in delivery across lessons contributed to the outcome.

The generalisability of findings is limited in important ways. The study was conducted in a single school in the Eastern Region of Ghana, involving two intact Visual Art classes. Findings may not transfer to schools with different socioeconomic profiles, school cultures, resource levels, or subject tracks. Furthermore, the intervention spanned only eight weeks, which is insufficient to determine whether the observed gains in interest and participation would be sustained over a full academic year or erode as novelty effects diminish. The exclusive focus on Form Two students also limits generalisability across year groups. Additionally, the intervention combined five distinct AfL strategies simultaneously, making it impossible to isolate which component or which combination drove the observed effects. Single-component or component-dismantling studies would be needed to determine the differential contribution of each strategy.

The study's dependence on self-reported Likert-scale data introduces inherent limitations. Self-report measures are known to be susceptible to response biases, including acquiescence bias and social desirability effects. Triangulating questionnaire data with observational measures of participation and qualitative data from student interviews would have provided a more robust and multi-dimensional assessment of the constructs. Despite these limitations, the study still contributes to the existing valuable evidence of literature on formative assessment in mathematics education and offers useful suggestions for future research.

Declarations

Funding: This research received no external funding.

Conflict of Interest: The authors declare no conflict of interest.

Author Contributions: All authors contributed, reviewed, and approved the final version.

Data Availability: The datasets generated and analyzed during this study are available from the corresponding author and can be made available upon request.

ACKNOWLEDGEMENTS

The authors extend their gratitude to the students who took part in the study and to the experts whose reviews, insights, and suggestions greatly contributed to improving this paper.

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