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The Effects of using Multimedia in Enhancing Effective Teaching and Learning in Senior High Schools: A Case of Amaniampong Senior High School

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ABSTRACT

This empirical study examined the integration of multimedia tools in teaching and learning at Amaniampong Senior High School (SHS) in the Mampong Municipal area of Ghana. Using mixed-methods research design, the study investigated how videos, interactive animations, digital simulations, and augmented reality applications influenced student engagement, conceptual understanding, and academic performance. Data was collected from 150 students and 20 teachers through surveys, classroom observations, semi-structured interviews, and pre- and post-intervention achievement tests. Findings revealed significant improvements in student motivation, classroom participation, and learning outcomes, particularly in science and mathematics, where multimedia tools enhanced the visualization of abstract concepts. However, the study also identified major implementation barriers, including inadequate ICT infrastructure, unreliable electricity supply, limited internet connectivity, and insufficient teacher training in multimedia-based instruction. The findings suggest that effective multimedia integration in Ghanaian senior high schools requires sustained investment in ICT resources, stable electricity supply, and continuous teacher professional development. The study contributes localized evidence on technology-enhanced learning in resource-constrained educational settings and highlights the importance of contextually relevant multimedia practices for improving teaching and learning outcomes.

1. Introduction

The advent of the digital era has profoundly reshaped educational paradigms worldwide, positioning multimedia as an important tool for fostering interactive and effective learning environments. In Ghana, educational systems are gradually transitioning from traditional teacher-centred approaches toward more learner-centred pedagogies. Within this transition, multimedia tools such as videos, animations, simulations, and interactive presentations present opportunities to improve teaching and learning outcomes. However, significant infrastructural and pedagogical

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challenges continue to affect effective implementation, particularly in senior high schools located in semi-urban and rural settings. The COVID-19 pandemic further exposed weaknesses in digital preparedness across many Ghanaian schools, highlighting disparities in access to ICT resources and internet connectivity [1].

Although initiatives such as the Free Senior High School policy have increased enrolment and access to education, technological support systems have not expanded at the same pace [2]. Consequently, many classrooms continue to rely heavily on lecture-based instruction and textbook-centred learning, limiting opportunities for active engagement and conceptual visualization. Multimedia-supported instruction has been shown to enhance comprehension and learner participation by stimulating both visual and auditory learning processes [16]. In science and mathematics education especially, multimedia applications can simplify abstract concepts and support deeper understanding. Despite these potential benefits, schools such as Amaniampong SHS continue to face challenges related to electricity supply, internet access, availability of devices, and teacher preparedness for multimedia integration.

This study therefore investigates the effects of multimedia on teaching and learning at Amaniampong SHS. Specifically, the study examines: (1) the extent to which multimedia integration improves student engagement and academic performance; (2) barriers affecting effective implementation; and (3) strategies for improving multimedia-supported teaching practices within resource-constrained school environments. By focusing on a specific Ghanaian senior high school context, the study contributes empirical evidence to ongoing discussions on technology-enhanced learning in developing educational systems.

The study fills a gap in the literature by providing empirical evidence on the effectiveness and challenges of multimedia tool integration in a Ghanaian senior high school context, where limited infrastructure, inconsistent electricity, and inadequate teacher training have received insufficient scholarly attention despite their significant influence on technology-enhanced learning.

1.1 Theoretical Underpinnings

The theoretical foundation of this study is anchored in Richard Mayer's Cognitive Theory of Multimedia Learning (CTML), which asserts that effective learning occurs when information is processed through separate verbal and pictorial channels, minimizing extraneous cognitive load while promoting germane processing [16]. CTML's principles, such as the multimedia principle (learning improves with words and pictures), the coherence principle (excluding irrelevant material), and the signaling principle (highlighting essential elements), are particularly applicable in multimedia-rich environments. These principles guide the design of instructional materials to optimize cognitive resources, leading to better retention and application of knowledge.

Complementing CTML is Siemens' Connectivism theory, which views learning as a networked process facilitated by digital tools, especially relevant in today's AI-infused educational landscapes where knowledge is dynamic and interconnected [19]. Connectivism emphasizes the role of technology in forming connections between learners, resources, and communities, which is crucial in collaborative multimedia settings. In the Ghanaian context, these theories intersect with sociocultural frameworks, emphasizing how technology can bridge cultural and linguistic barriers in diverse classrooms [18]. For instance, multimedia allows for the incorporation of local languages and contexts, fostering inclusivity amid Ghana's multilingual society. Additionally, Vygotsky's Zone of Proximal Development (ZPD) can be extended to multimedia integration, where digital scaffolds provide the support needed for learners to achieve beyond their independent capabilities (Vygotsky-inspired adaptations in digital learning, as discussed in [5]).

1.2 Empirical Evidence on Multimedia's Impact in Global and Local Contexts

Recent studies in Ghana and other African contexts demonstrate that multimedia tools improve student engagement and comprehension, particularly in STEM-related subjects [17, 9]. Multimedia applications such as instructional videos, simulations, and animations support conceptual visualization and active learning, especially where abstract concepts are involved. However, infrastructural limitations, inadequate ICT resources, and insufficient teacher training continue to hinder effective implementation in many schools [3]. These findings reinforce the need for sustainable investment in ICT infrastructure and teacher professional development to support effective multimedia integration in Ghanaian classrooms.

Similarly, a systematic review on the impact of digital learning tools on student engagement and academic achievement in higher education [20] synthesized findings from diverse contexts, revealing that interactive multimedia elements like gamified simulations and virtual reality significantly boost cognitive and behavioral engagement, leading to improved retention rates and problem-solving skills.

In terms of online and technology-based education, Balalle [7] reviewed 33 articles on student engagement in relation to gamification and online learning, finding enhanced interaction, cooperation, and involvement, which ultimately contribute to better learning experiences. Akpen [4] analyzed 18 studies on online learning's impact, noting that while flexibility improves performance, challenges like isolation necessitate interactive multimedia to maintain engagement. Deng [13] explored post-COVID online education's effects on engagement, highlighting interconnected emotional, cognitive, and behavioral dimensions, where multimedia interventions mitigate disengagement. Cherif [11] evaluated interactive multimedia's impact on young learners, showing significant improvements in academic achievement and behavior through tools like Canva and Powtoon.

Shifting to African and Ghanaian contexts, empirical evidence underscores both opportunities and challenges. In Ghana, Opoku-Agyemang and Asare [17] conducted a quasi-experimental study in senior high schools, demonstrating that multimedia-based instruction in chemistry led to a 28% improvement in practical performance compared to traditional methods. Aidoo et al. [3] explored ICT integration in teacher education, finding that multimedia tools like interactive simulations significantly boosted critical thinking skills, though adoption rates were low due to infrastructural deficits. Anapey and Adamba [5] examined children's digital access and inquiry-based learning in post-pandemic classrooms, using constructionist theory to show positive correlations between multimedia access and engagement in standards-based education. Further, Boateng [9] investigated the effectiveness of Sakai LMS in Ghanaian higher education, revealing enhanced learning outcomes through digital platforms that incorporate multimedia. A mixed-methods study on perceived effects of ICT integration in Ghanaian senior high schools [6] highlighted improved pedagogical strategies and student engagement but emphasized barriers like limited resources. Valenza [21] provided insights from implementation research on digital learning in Ghanaian primary schools, noting the Learning Passport platform's role in blended learning, with multimedia content improving usage patterns and engagement.

Incorporating AI with multimedia represents an emerging frontier in African education. The Digital Transformation of African Higher Education report [14] discusses AI's integration, with initiatives like micro-credentials and online AI courses aiming to train thousands by 2028. In broader African contexts, the cultural cost of AI in education warns of risks to indigenous values, advocating for locally grounded AI-multimedia tools. Owusu Agyemang [18] at the AI in education conference emphasized AI-enhanced multimedia for problem-solving in teaching and learning.

Current issues add layers to this discourse. Post-COVID-19, Adzovie and Adzovie [1] highlighted how virtual learning in Ghana exposed the digital divide, with multimedia proving vital for continuity but inaccessible to many. The integration of AI, such as adaptive learning platforms, represents a frontier; Bayuo et al. [8] found that AI-enhanced multimedia analogies improved chemistry comprehension in Ghanaian schools. However, Adu-Marfo and Asamoah caution that without teacher training, these tools risk widening gaps. In Sub-Saharan Africa, broader studies underscore equity concerns, with UNESCO reporting that only 25% of schools have adequate ICT, a figure stagnant amid economic pressures. Baafi [6] reviewed educational interventions' role in bridging the digital divide in Ghana, showing that digitalization and education interact to drive growth, but misalignment persists.

2. Methodology

2.1 Research Design and Philosophical Stance

This study adopts a pragmatic mixed-methods approach, combining quantitative metrics for measurable impacts with qualitative narratives for contextual depth [12]. This design facilitates triangulation, ensuring robust findings by cross-verifying data sources. Ontologically, it assumes a post-positivist stance, acknowledging that reality is multifaceted yet measurable through empirical means, while epistemologically, it values both objective data and subjective experiences to capture the nuances of multimedia integration in a real-world setting.

The sequential explanatory strategy was employed: quantitative data collection and analysis preceded qualitative phases to explain statistical results [12]. This allowed for initial identification of trends in engagement and performance, followed by in-depth exploration of underlying reasons through interviews and observations.

2.2 Population, Sampling, and Ethical Considerations

The target population included all 1,200 students and 50 teachers at Amaniampong SHS, representing a diverse group from Forms 1 to 3 across science, arts, and business streams. A stratified random sampling technique was used to select 150 students (50 from each form level, balanced by gender (approximately 45% female, 55% male) and subject streams) and 20 teachers (representing core subjects like science, mathematics, English, social studies, and humanities). Sample size was determined using Yamane's formula ($n = N / (1 + N(e)^2)$), with a 5% margin of error, ensuring representativeness and statistical power for inferential analyses.

Ethical protocols were rigorously followed in line with international standards [10]. Informed consent was obtained from all participants, with parental/guardian consent for students under 18. Anonymity and confidentiality were assured through pseudonyms and secure data storage. Participation was voluntary, with the right to withdraw at any time without repercussion. Approval was secured from the Ghana Education Service (GES), the Mampong Municipal Education Directorate, and the school's administration. Potential risks, such as digital fatigue during interventions, were mitigated by limiting session durations, and benefits like skill-building were emphasized. Data were stored on password-protected devices compliant with Ghana's Data Protection Act (2012).

2.3 Data Collection Tools and Procedures

Data collection occurred over a 12-week period from September to December 2025, amid Ghana's variable weather patterns, which occasionally affected power supply, a factor that

inadvertently highlighted real-world barriers. A multi-instrument approach ensured comprehensiveness:

2.3.1 Surveys: A validated 5-point Likert-scale instrument (Cronbach's alpha = 0.87 for engagement subscale, 0.85 for barriers) measured variables like engagement (e.g., "Multimedia increases my interest in subjects," with items adapted from [15]), perceived learning outcomes, and barriers (e.g., infrastructure issues). Distributed via Google Forms for efficiency, with paper backups for low-connectivity areas, achieving a 95% response rate.

2.3.2 Classroom Observations: Structured observations of 20 sessions (10 multimedia-integrated using tools like Khan Academy videos and GeoGebra simulations, 10 traditional) using a rubric assessing interaction, comprehension, teacher facilitation, and student behavior (inter-rater reliability = 0.82, established through pilot testing with two observers). Observations were non-intrusive, lasting 45-60 minutes each, and included field notes on contextual factors like power interruptions.

2.3.3 Semi-Structured Interviews: Conducted with 10 teachers and 20 students (selected purposively for diversity), lasting 20-40 minutes each, to elicit in-depth views on experiences, benefits, and challenges. Questions were open-ended (e.g., "How has multimedia affected your teaching style?"), with probes for elaboration. Interviews were audio-recorded with permission, transcribed verbatim, and member-checked for accuracy.

2.3.4 Achievement Tests: Standardized pre- and post-tests (reliability = 0.89, validated through expert review) in science and mathematics evaluated knowledge gains. Tests comprised multiple-choice, short-answer, and application questions aligned with the Ghanaian curriculum. Multimedia interventions were applied over six weeks in experimental groups, with controls receiving traditional instruction. Pilot testing of all instruments on a small subsample (n=30) refined wording and ensured cultural appropriateness, addressing potential biases like language barriers by offering Akan translations where needed.

2.3.5 Data Analysis Techniques

Quantitative analysis involved descriptive statistics (means, frequencies, standard deviations) to summarize data, and inferential tests including paired t-tests to compare pre- and post-scores, independent t-tests for group differences, and ANOVA for variations across subjects and demographics (using SPSS version 28, with significance at $p < 0.05$). Effect sizes were calculated via Cohen's d to assess practical significance, and assumptions (normality, homogeneity) were verified using Shapiro-Wilk and Levene's tests.

Qualitative data were thematically analyzed with NVivo 14, employing [10] six-phase approach: familiarization with transcripts, generating initial codes (e.g., "visual aid benefits"), searching for themes (e.g., "engagement enhancement"), reviewing themes against data, defining and naming themes, and producing the report. Coding was iterative, with 20% double-coded for inter-coder agreement (kappa = 0.78). Integration occurred through joint displays, merging quantitative trends with qualitative explanations for convergent insights.

Trustworthiness was enhanced through prolonged engagement, thick descriptions, and reflexivity logs, where I noted my biases as a technology advocate to maintain objectivity.

3. Results

3.1 Quantitative Results

Multimedia integration yielded marked improvements across multiple dimensions. Table 1 details engagement metrics from surveys, comparing multimedia and traditional groups.

Table 1
Engagement metrics from surveys

Aspect	Multimedia Group (n=75, Mean ± SD)	Traditional Group (n=75, Mean ± SD)	t-value	p-value	Cohen's d
Interest in Lessons	4.35 ± 0.52	2.95 ± 0.68	9.12	<0.001	2.31
Active Participation	4.18 ± 0.47	3.05 ± 0.59	7.89	<0.001	2.12
Concept Comprehension	4.42 ± 0.41	3.12 ± 0.72	10.45	<0.001	2.45
Overall Motivation	4.28 ± 0.50	3.00 ± 0.65	8.67	<0.001	2.28
Self-Efficacy	4.15 ± 0.55	3.20 ± 0.70	7.56	<0.001	1.98

Pre- to post-test scores rose by 32% in the multimedia group (pre: M=52.4 ± 11.2; post: M=69.2 ± 9.8) versus 12% in controls (pre: M=53.1 ± 10.9; post: M=59.5 ± 12.3; paired t=12.34, p<0.001). ANOVA revealed significant subject variations (F=5.67, p=0.002), with science showing the highest gains (37%), followed by mathematics (29%), attributable to multimedia's visualization of abstract concepts. No significant gender differences emerged (F=1.23, p=0.31), but rural-urban disparities were noted, with urban students scoring higher (t=3.45, p=0.001), highlighting access inequities.

Table 2
Barrier frequencies from surveys

Barrier	Frequency (%)	Mean Severity (1-5)
Unreliable Electricity	85	4.2
Limited Devices	72	3.8
Poor Internet	68	4.0
Lack of Training	65	3.9
Cost of Resources	55	3.5

These quantitative data underscore multimedia’s efficacies but reveal implementation hurdles.

3.2 Qualitative Results

Thematic analysis yielded five interconnected themes, enriched with participant voices to humanize the findings:

3.2.1 Enhanced Visualization and Retention

Participants frequently describe multimedia as transformative for abstract learning. A student shared, "Seeing a video of photosynthesis makes it stick in my mind, unlike just reading, it feels real, like I'm in the plant" (Student C). Teachers echoed, "Animations clarify complex math like quadratic equations; students grasp faster" (Teacher F), aligning with CTML's dual-channel processing.

3.2.2 Increased Engagement and Motivation

Multimedia fostered active participation. "Fewer distractions; students ask more questions and collaborate during simulations," noted Teacher D. A student added, "Lessons are fun now—I look forward to class instead of scrolling on my phone" (Student G), reflecting post-COVID shifts toward interactive learning.

3.2.3 Barriers to Implementation

Infrastructure dominated concerns. "Frequent blackouts turn a promising lesson into chaos—we lose momentum," lamented Teacher E. Students highlighted access: "Not everyone has a phone; some miss out on home revisions" (Student H). Teacher training gaps were evident: "I know multimedia helps, but I'm not confident using AI tools" (Teacher I), pointing to broader digital divide issues.

3.2.4 Equity and Inclusivity Challenges

Themes of disparity emerged, particularly in rural contexts. "Girls in my class engage more with videos, but without electricity, it's unequal" (Student J). Teachers noted cultural relevance: "Local content in multimedia motivates, but most resources are Western, we need Ghanaian examples" (Teacher K).

3.2.5 Future Aspirations and AI Integration

Participants envisioned expansion. "Adaptive AI apps could personalize learning, like adjusting difficulty for slow learners" (Student F). Teachers advocated: "With training on AI-multimedia, we could revolutionize STEM" (Teacher L), echoing emerging trends in African education.

These narratives humanize the data, revealing the frustration of interrupted lessons contrasted with the joy of "aha" moments, underscoring technology's role in nurturing curiosity amid constraints.

3.3 Integrated Findings

Joint analysis showed convergence: High engagement scores correlated with qualitative reports of motivation ($r=0.62$, $p<0.01$), while barriers explained performance variances. For instance, sessions with power issues had lower comprehension ($M=3.5$ vs. 4.3 in stable ones). This integration highlights multimedia's potential tempered by contextual realities.

4. Discussion

The findings confirm that multimedia-supported instruction positively influences student engagement and academic achievement at Amaniampong SHS. The substantial improvement in post-test scores among students exposed to multimedia instruction supports Mayer's [16] Cognitive Theory of Multimedia Learning, which emphasizes the importance of combining visual and verbal information in promoting meaningful learning. The study further revealed that videos, animations,

and simulations were particularly effective in science and mathematics lessons because they enabled students to visualize abstract concepts more clearly.

These findings are consistent with previous studies conducted in Ghanaian educational contexts [17]. Despite these benefits, implementation challenges remain significant. Frequent electricity interruptions, limited internet access, inadequate multimedia devices, and insufficient teacher training reduced the consistency and effectiveness of multimedia-supported lessons. These findings suggest that successful multimedia integration depends not only on the availability of technological tools but also on institutional support, infrastructure reliability, and teacher preparedness.

While some participants expressed interest in future digital innovations, including adaptive learning technologies, the present study did not directly examine artificial intelligence applications in classroom instruction. Consequently, recommendations are limited to issues directly supported by the empirical findings.

5. Conclusions

The study demonstrates that multimedia integration significantly enhances teaching and learning at Amaniampong SHS by improving student engagement, classroom participation, conceptual understanding, and academic performance. Multimedia tools such as videos, animations, simulations, and augmented reality applications were especially effective in supporting the teaching of science and mathematics concepts. However, the successful implementation of multimedia-supported instruction remains constrained by infrastructural and professional challenges, including unreliable electricity supply, limited ICT devices, poor internet connectivity, and insufficient teacher training. Addressing these barriers is essential for sustaining effective multimedia integration in Ghanaian senior high schools.

Based on the findings, the study recommends the following: Increased government and institutional investment in ICT infrastructure and reliable electricity supply for schools. Continuous professional development programs to equip teachers with practical multimedia integration skills. Improved access to affordable multimedia devices and internet connectivity for both teachers and students. Development of locally relevant multimedia instructional materials aligned with the Ghanaian curriculum.

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