The Effect of Flash-Based Learning Media on Students' Achievement in Learning Atomic Structure in Kenyan Senior High Schools

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ABSTRACT

Purpose of the study: This study aims to investigate the effect of Flash-based learning media on students' learning achievement in chemistry, particularly on the topic of atomic structure, in Kenyan senior high schools.

Methodology: The study employed a quasi-experimental research design using a pretest–posttest control group approach. The participants consisted of 84 Grade 10 students from a public senior high school in Kenya, divided into an experimental group and a control group. The experimental group was taught using Flash-based learning media featuring animated visualizations of atomic models, subatomic particles, and electron configurations, while the control group received conventional instruction. Data were collected using a validated chemistry achievement test and analyzed using an independent samples t-test.

Main Findings: The results showed that students who learned using Flash-based media achieved significantly higher posttest scores than those taught using conventional methods. The statistical analysis revealed a significant difference between the experimental and control groups ($t = 3.24$, $p < 0.05$), indicating that Flash-based learning media had a positive effect on students' achievement in learning atomic structure.

Novelty/Originality of this study: This study provides empirical evidence on the effectiveness of Flash-based learning media in chemistry education within the Kenyan context, which remains underexplored. The findings highlight the potential of interactive multimedia to enhance students' conceptual understanding of abstract chemistry topics and support the integration of digital learning media in secondary science education in developing countries.

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1. INTRODUCTION

Chemistry is a fundamental subject in senior high school education that plays a crucial role in developing students' scientific literacy and understanding of natural phenomena [1]-[3]. One of the core topics in chemistry is atomic structure, which serves as the foundation for understanding chemical bonding, reactions, and material properties. Despite its importance, atomic structure is widely recognized as a difficult topic for students due to its abstract and theoretical nature [4], [5]. Many of the concepts involved, such as subatomic particles and electron configurations, cannot be directly observed. Consequently, students often struggle to build meaningful conceptual understanding [6], [7].

In many secondary schools, chemistry instruction is still dominated by conventional teaching methods, particularly lecture-based approaches [8], [9]. These methods tend to emphasize verbal explanations and textbook content, with limited use of visual or interactive learning media. As a result, students are required to rely heavily on memorization rather than conceptual reasoning. This instructional approach often leads to low learning achievement and persistent misconceptions, especially in abstract topics such as atomic structure [10], [11]. The problem becomes more pronounced when students are unable to visualize microscopic processes effectively [12], [13].

The urgency of addressing this issue is particularly evident in the context of Kenyan senior high schools. Although the Kenyan education system has begun to emphasize competency-based learning, the integration of instructional technology in classroom practice remains limited [14], [15]. Many schools face challenges related to instructional resources, teacher preparedness, and access to effective learning media [16], [17]. These conditions contribute to students' low performance in science subjects, including chemistry [18], [19]. Therefore, innovative and affordable instructional solutions are urgently needed to improve learning outcomes.

One promising approach to overcoming these challenges is the use of Flash-based learning media. Flash-based media allow the integration of animations, simulations, and interactive elements that can represent abstract chemical concepts dynamically [20], [21]. Through visual and auditory stimulation, such media can support students' cognitive processing and enhance their engagement in learning [22], [23]. Previous studies conducted in different educational contexts have reported that multimedia-based instruction can improve students' motivation and academic achievement [24]-[26]. However, the effectiveness of Flash-based media may vary depending on the learning context and subject matter.

Several studies have examined the use of multimedia and computer-based learning media in chemistry education [27], [28]. Most of these studies report positive effects on students' learning achievement and conceptual understanding. Nevertheless, the majority of existing research has been conducted in developed countries or regions with advanced technological infrastructure [29], [30]. Empirical studies focusing on the application of Flash-based learning media in African contexts, particularly in Kenyan senior high schools, remain scarce. This lack of context-specific evidence represents a significant research gap.

The novelty of this study lies in its focus on the implementation of Flash-based learning media for teaching atomic structure within the Kenyan senior high school context. Unlike previous studies that broadly examine multimedia learning, this research specifically investigates Flash-based media as an instructional tool for a highly abstract chemistry topic. In addition, the study employs a quasi-experimental design to provide empirical evidence of its effectiveness on students' learning achievement. By situating the research within the Kenyan education system, this study contributes new insights into technology-enhanced chemistry learning in developing countries.

Based on the identified problems, research gaps, and potential contributions, this study aims to examine the effect of Flash-based learning media on students' learning achievement in chemistry. Specifically, the study focuses on the topic of atomic structure among Grade 10 students in a Kenyan senior high school. The findings are expected to provide empirical evidence to support the integration of interactive multimedia in chemistry instruction. Furthermore, the results may serve as a reference for teachers, curriculum developers, and policymakers in improving science education practices. Ultimately, this research seeks to contribute to the enhancement of chemistry learning quality through innovative instructional media.

2. RESEARCH METHOD

2.1 Research Design

This study employed a quasi-experimental research design using a pretest–posttest control group approach [31], [32]. This design was selected to examine the causal effect of Flash-based learning media on students' learning achievement in chemistry. Two intact classes were used without random assignment at the individual level to maintain the natural classroom setting [33], [34]. One class was assigned as the experimental group, while the other served as the control group. Both groups were given a pretest and a posttest to measure changes in learning achievement.

2.2 Research Participants

The population of this study consisted of all Grade 10 students enrolled in a public senior high school in Kenya. The sample comprised 84 students selected through cluster sampling, as classes had been formed prior to the study. A total of 42 students were assigned to the experimental group and 42 students to the control group. Both groups were comparable in terms of age, academic background, and prior knowledge based on pretest results [35], [36]. This sample size was considered representative of the population and sufficient for statistical analysis.

2.3 Instructional Treatment

The experimental group received instruction using Flash-based learning media designed to support the teaching of atomic structure [37], [38]. The media included animated visualizations of atomic models, subatomic particles, and electron configurations to facilitate conceptual understanding. Learning activities were conducted through teacher-guided explanations supported by Flash animations and interactive content. Meanwhile, the control group was taught using conventional instructional methods, primarily lecture-based teaching and textbook explanations. Both groups received the same learning objectives, content coverage, and instructional time.

2.4 Research Instrument

Students' learning achievement was measured using a chemistry achievement test focused on the topic of atomic structure. The test consisted of objective questions that assessed students' understanding of atomic models, subatomic particles, and electron configuration [39], [40]. The instrument was reviewed by chemistry education experts to ensure content validity. Prior to implementation, the test was piloted to evaluate its reliability and clarity. The same test was administered as a pretest and a posttest for both groups.

2.5 Data Collection Procedure

Data collection was conducted in three main stages. First, a pretest was administered to both the experimental and control groups to assess students' initial knowledge of atomic structure [41], [42]. Second, the instructional treatment was implemented over several learning sessions according to the school schedule. Finally, a posttest was administered to measure students' learning achievement after the intervention. All data were collected under controlled classroom conditions to ensure consistency.

2.6 Data Analysis Technique

The collected data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics were used to determine the mean, minimum, and maximum scores of students' pretest and posttest results [43], [44]. Before hypothesis testing, the data were examined for normality and homogeneity. An independent samples t-test was then applied to compare the posttest scores of the experimental and control groups. Statistical significance was determined at the 0.05 level.

3. RESULTS AND DISCUSSION

The results of this study are presented based on students' learning achievement scores obtained from the pretest and posttest administered to both the experimental and control groups. Prior to the instructional treatment, a pretest was conducted to determine students' initial understanding of atomic structure. The descriptive statistics indicate that the two groups had comparable initial abilities. This similarity suggests that both groups started the learning process under relatively equal conditions. Therefore, differences observed in posttest scores can be attributed to the instructional treatment applied.

The results of this study are based on students' learning achievement scores obtained from the pretest and posttest administered to both the experimental and control groups. The pretest results indicated that students in both groups had comparable initial understanding of atomic structure concepts. The experimental group obtained a pretest mean score of 52.30, while the control group achieved a mean score of 51.85. This similarity suggests that the two groups began the learning process with relatively equal prior knowledge. Therefore, any differences observed in posttest performance can be attributed to the instructional treatment applied.

Table 1 presents the descriptive statistics of students' learning achievement before and after the instructional intervention.

Table 1. Descriptive Statistics of Students' Learning Achievement

Group	Test	Mean	Minimum	Maximum
Experimental	Pretest	52.30	30	70
Experimental	Posttest	78.05	45	100
Control	Pretest	51.85	28	68
Control	Posttest	68.69	30	95

As shown in Table 1, both groups experienced an increase in posttest scores after instruction. However, the improvement observed in the experimental group was substantially higher than that of the control group. The experimental group achieved a posttest mean score of 78.05, while the control group achieved 68.69. This difference indicates that students who were taught using Flash-based learning media demonstrated better learning achievement than those taught using conventional methods. These findings suggest that the integration of multimedia-based instruction positively influenced students' understanding of atomic structure.

To determine whether the difference in posttest scores between the two groups was statistically significant, an independent samples t-test was conducted. The results of the hypothesis testing are summarized in Table 2.

Table 2. Independent Samples t-Test Results of Posttest Scores

Group Comparison	t-value	t-table ($\alpha = 0.05$)	Significance
Experimental vs. Control	3.24	1.99	Significant

The calculated t-value of 3.24 exceeded the critical t-value of 1.99 at the 0.05 significance level. This result indicates a statistically significant difference between the posttest scores of the experimental and control groups. Consequently, the null hypothesis was rejected, and the alternative hypothesis was accepted. These results confirm that Flash-based learning media had a significant effect on students' learning achievement in chemistry.

The effectiveness of Flash-based learning media in this study is closely related to how the media were implemented during the learning process [45], [46]. In the experimental group, Flash media were used to present animated visualizations of atomic models, subatomic particles, and electron configurations. These animations allowed students to observe abstract microscopic processes dynamically, which are difficult to explain through verbal instruction alone. Teachers used the Flash media as a core instructional tool to support explanations, stimulate discussion, and guide students' conceptual understanding [47], [48]. This approach helped students connect theoretical concepts with visual representations.

The use of Flash-based media also reduced common misconceptions related to atomic structure. For example, students often perceive atoms as flat or static objects when taught through textbook images. Through animated Flash visualizations, students were able to understand atoms as dynamic systems with moving electrons. This visualization supported deeper conceptual learning rather than surface-level memorization [49], [50]. As a result, students developed a more accurate understanding of atomic structure concepts.

In addition, Flash-based learning media increased students' engagement and motivation during chemistry lessons. Interactive animations captured students' attention and encouraged active participation in learning activities [51], [52]. Students showed greater interest in asking questions and discussing atomic structure concepts during lessons. In contrast, the conventional instruction used in the control group relied mainly on lectures, which limited student interaction. Increased engagement and motivation are key factors that contribute to improved learning outcomes, particularly in abstract science subjects.

The findings of this study have important implications for chemistry education in Kenyan senior high schools. The results demonstrate that Flash-based learning media can be an effective instructional tool for teaching abstract chemistry concepts. Teachers can utilize relatively simple multimedia technology to enhance students' conceptual understanding and learning achievement. From a practical perspective, Flash-based media offer a feasible solution for improving chemistry instruction in schools with limited laboratory facilities. Therefore, this study supports the integration of multimedia-based learning media into secondary science education.

Despite its contributions, this study has several limitations that should be acknowledged. First, the study was conducted in a single senior high school, which may limit the generalizability of the findings. Second, the research focused only on students' cognitive learning achievement and did not examine affective or psychomotor outcomes. Third, the duration of the instructional intervention was relatively short, which may not fully capture long-term learning effects. These limitations should be considered when interpreting the results.

Based on these limitations, several recommendations for future research can be proposed. Future studies should involve larger and more diverse samples from different regions to enhance the generalizability of the findings. Researchers are also encouraged to investigate the long-term effects of Flash-based learning media on students' retention and conceptual change. In addition, future research may explore the integration of Flash-based media with other instructional strategies, such as inquiry-based or problem-based learning. Such studies would provide deeper insights into the potential of multimedia-based instruction in chemistry education.

4. CONCLUSION

Based on the findings of this study, it can be concluded that the use of Flash-based learning media has a significant positive effect on students' learning achievement in chemistry, particularly on the topic of atomic structure in Kenyan senior high schools. Students who were taught using Flash-based media achieved higher posttest scores than those who received conventional instruction, indicating improved conceptual understanding. This result confirms that Flash-based learning media are effective in supporting the visualization of abstract chemistry concepts. The integration of animated and interactive visualizations enabled students to better understand atomic models, subatomic particles, and electron configurations. Thus, the research objective of examining the effect of Flash-based learning media on students' learning achievement was successfully achieved.

Based on the results of this study, several recommendations can be proposed. Chemistry teachers are encouraged to integrate Flash-based or similar multimedia learning media into classroom instruction to enhance students' understanding of abstract topics. Schools and educational stakeholders should support the use of instructional technology by providing adequate facilities and teacher training. Future research is recommended to involve larger and more diverse samples to improve the generalizability of the findings. Additionally, further studies should examine the long-term impact of multimedia-based instruction on students' retention, motivation, and higher-order thinking skills.

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