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Effects of Multimedia Technology Integration on Students' Achievement in Chemistry in Co-Educational Secondary Schools in Bomet County, Kenya

Victor Kiplangat Rotich[1], William Orora[2], John K. Keter[3]

[1, 2]Department of Curriculum Instruction and Educational Management, Egerton University
[3]Department of Curriculum, Instruction and Educational Media, University of Kabianga

Corresponding Author:** ***John K. Keter, *Department of Curriculum, Instruction and Educational Media, University of Kabianga.* ***Email:*** *johnketer96@gmail.com*

Abstract: *This paper examined the effect of Multimedia Technology Integration (MTI) in teaching on students' achievement in Chemistry in Bomet County, Kenya. It adopted the Solomon-Four non-equivalent control group research design. The accessible population comprised of form three students in co-education schools in Bomet which offer Chemistry. Purposive sampling technique was used to select 4 Co-educational secondary schools that were involved in the study. Two schools were randomly assigned to Experimental groups while the other two constituted the Control groups. A sample of 208 students participated in the study. Data was collected using Mole Achievement Test (MAT). The face and content validity of the instrument were checked through expert judgement. The reliability of MAT was estimated using the Kuder Richardson (KR21) formula. The instrument was deemed reliable as it yielded a coefficient of 0.701. Hypothesis were tested at the .05 significance level using the t-test and ANOVA. The findings showed a significant difference in achievement between students exposed to MTI and those taught using Conventional Teaching Methods (CTM) in favour of the Experimental groups. The paper concludes that MTI improves students' achievement in Chemistry better than CTM. It recommends that MTI be blended with other factors that enhance performance to boost students' achievement in Chemistry.*

Keywords: *Multimedia Technology Integration, Secondary School, Chemistry Achievement*

1. INTRODUCTION

Chemistry is a branch of science which provides learners with knowledge and ability to understand the composition, properties and changes in behaviour of matter that form the environment (Irwanto et al., 2022). Chemistry is offered as a subject in secondary schools, colleges and universities globally (Stojanovska et al., 2020). The knowledge and skills acquired through Chemistry education contribute significantly to solving problems encountered by man in their day-to-day life. Chemistry has contributed significantly to development of Health, Agriculture and Industrial sectors of nations. For instance, in the health sector, knowledge and skills in Chemistry has helped in production of new drugs and improving existing ones (Rafique et al., 2024). In the Agricultural sector, competencies in Chemistry plays a key role in soil analysis, development of fertilizers, chemicals required to control pests and diseases in crops and livestock (Kumar, 2022). Knowledge and skills in Chemistry aids in enhancing efficiency of processes and reduction of dependence on natural material as inputs of production in industries (Abulkosimovich & Bakhtiyorovna, 2023).

1.1. Secondary School Chemistry in Kenya

Chemistry is among the core science subjects offered in secondary schools in Kenya (Otieno et al., 2020). The general objectives of teaching Chemistry under the 8-4-4 education system that is being phased out is for students to acquire knowledge and skills and use them to solve everyday life problems (Kenya Institute of Curriculum Development, 2017). The other general objectives of teaching the subject are to enable learners apply Chemistry principles and skills acquired in technological and industrial development of Kenya and for further education and training. Under the current education system, Curriculum Based Curriculum (CBC), that is replacing the 8-4-4 model, the general objectives of secondary school Chemistry are to equip learners with knowledge, competencies, attitudes, and

values which will enable them flourish in the ever changing global economy that is characterized by shifting technological demands and advancements of the 21st century (KICD, 2019). It is envisaged that CBC will produce skilled labour that will enable Kenya to achieve her industrial and economic ambitions set forth in Kenya Vision 2030 (Muchira et al., 2024).

1.2. Students' Performance in Chemistry

Chemistry plays an important role in equipping students with knowledge and skills of the 21st century, such are problem-solving skills, creativity and innovation (Musengimana et al., 2021). Despite the importance of Chemistry, students achievement in the subject in national examinations has perennially been below average. For example, students' mean grades in the subject for the years 2019, 2020, 2021, 2022 and 2023 were 5.88, 5.89, 5.88, 5.96 and 5.99 respectively (KNEC, 2022, 2024). This data confirms that achievement in the subject has been below average given that the grades are out of 12. Reports from KNEC also indicate that achievement in the subject in counties such as Bomet has been has been unsatisfactory. The mean grades in the subject obtained by students in Bomet county for the years 2019, 2020, 2021, 2022 and 2023 were 3.66, 3.70, 3.82, 3.83 and 4.12 (County Director of Education, 2024).

The Mole is a fundamental topic in Chemistry that relates the mass of a substance to the number of particles it contains (Dragseth, 2019). Mastery of it's concepts is a requirement in the learning of other topics in Chemistry. Reports from KNEC indicate that Mole topic is among those that students consider difficult (KNEC, 2024). The topic thus contributes significantly towards the below average achievement in Chemistry. This explains why the Mole as a topic was the focus of this paper.

1.3. Determinants of Achievement in Chemistry

Studies indicate that students' achievement in Chemistry is affected by many factors (Chikendu, 2022; Malala et al., 2021). Hashi et al. (2025) noted that availability and use of instructional materials positively affected students' academic achievement. A study by Bedada and Fita (2023) found that lack of school facilities such as library and Chemistry laboratories, shortage of qualified and experienced teachers and limited parental involvement in their children studies affected students' academic achievement in Chemistry. Sibomana et al. (2021) established that negative attitudes towards Chemistry, use of inappropriate teaching strategies and students' misconceptions of the subject impacted on their academic achievement. Multimedia Technologies Integration (MTI) in teaching has also been cited as one of the predictors of achievement in Chemistry (Otianga et al., 2019; Vagg et al., 2020).

1.4. Impact of Integration of Multimedia Technologies in Teaching on Achievement in Chemistry

Extant literature shows that integration of multimedia technologies in teaching significantly enhance achievement of set outcomes (Dupchu, 2023; Igori et al., 2019; Ukamaka & Egolum, 2023). Media technology integration refers to the use of technologies to enhance student learning experiences utilizing a variety of Information Communication and Technology (ICT) resources in the classroom (Hadiza et al., 2024). The resources include a blend of texts, static images, animation, virtual classroom, slide decks, videos, info-graphics and podcasts. MTI is learner centered unlike Conventional Teaching Methods (CTM), which focuses on the teacher, mainly use the lecture and emphasises rote learning (Kumar, 2022) Tauber et al. (2022) contends that integrating multimedia technologies in teaching enhances achievement because it provides students with opportunities to actively engaged in learning. MTI also creates pathways for differentiated instruction which meets the unique needs of individual learners within a broader classroom climate.

Integration of multimedia technology in teaching has been associated with enhanced students' achievement by several scholars. A study in Germany by Wohlfart et al. (2024) noted that integration of subject-specific digital tools in teaching had the potential to enhance realization of learning outcomes. Yesgat et al. (2023) conducted a study on effects of technology-integrated chemistry instruction on students' academic achievement in Ethiopia. The results revealed that students exposed to technology obtained a higher mean score, which was significantly different from that of their counterparts taught using CTMs. Otianga's et al. (2019) study conducted among secondary school students concluded that integration of ICT in the teaching of Chemistry positively influenced realization of set learning objectives.

Evidence from the foregoing studies reviewed show that integration of multimedia technology in teaching has to potential to improve students' achievement in Chemistry. It can thus be adopted by instructors to improve achievement in Chemistry in schools that have been posting below average performance in the subject. It is against this background that the paper investigated effects of Integration of Multimedia Technology in teaching on students' achievement in Chemistry in co-educational secondary schools in Bomet County, Kenya.

2. HYPOTHESIS

HO1: There is no statistically significant difference in students' achievement in Chemistry between those to MTI and those taught using CTM.

3. METHODOLOGY

3.1. Research Design

The Quasi-experimental Solomon Four Non-Equivalent Control Group research design was adopted during this study. Respondents in this design are randomly assigned to four groups, two experimental (E1 and E2), and two control groups, C1 and C2 (Andrade, 2021). Experimental groups are exposed to treatment while the Control groups are taught using CTM. At the end of the programme, all the four groups were given a post-test. The design was selected because it handles threats to internal and external validity well (Takahashi & Oo, 2020). The selection of this design was also based on the fact that it allows researchers to use intact classes, given that it is unethical and contrary to Ministry of Education regulations to reconstitute classes for research purposes (Wango, 2009).

3.2. Target Population and Sampling

This study was conducted in Bomet County, Kenya. The County has a total of 271 secondary schools, 262 are public while 9 are private institutions (County Government of Bomet, 2023). The total student population in public secondary schools when the study was conducted was 52,251. The target population of this study was all 12,953 form three Chemistry students in public secondary schools in the county (County Director of Education, 2024). The accessible population was 7321 form three students in public co-education secondary schools in Bomet County.

Purposive sampling technique was used to select four co-educational schools that participated in the study. Only schools that met the requirements, had computers, laboratories, apparatus and qualified Chemistry teachers, were selected. Intact form 3 classes in single stream schools were involved in the study while simple random sampling techniques were used to select the participating class in schools with more than one form three streams. A total of 208 Form 3 students, E1= 52, E2 = 49, C1 = 56 and C2 = 51, took part in the study.

3.3. Data Collection and Analysis

Data was collected using Mole Achievement Test, which was marked out of 20. The face and content validity of MAT was checked through expert judgement. The reliability of the instrument was also estimated using Kuder Richardson 21 formula. MAT yielded a coefficient of 0.701, which is an indication that it was reliable. MAT was administered to E1 and C1 as a pre-test before commencement of the programme. After pretesting, E1 and E2 were taught the topic Mole using MTI for 4 weeks. Groups C1 and C2 were also taught the topic for the same period of time using conventional methods. MAT was administered as a post-test to all the four groups after the intervention. The collected data was checked for errors, cleaned, coded and keyed into a file and analyzed with the aid of the Statistical Package for Social Science. Hypothesis was tested at .05 significant level using the t-test and Analysis of Variance (ANOVA). Before conducting the t-test and ANOVA, diagnostic tests were conducted to ascertain that the underlying parametric assumptions associated with them such as normality of data and equality of variance were not violated. The diagnostic test results indicated that the assumptions were not violated.

4. RESULTS AND DISCUSSION

Pre-test analysis was carried out prior to testing the study hypotheses. The analysis involved groups E1 and C1 and assisted in ascertaining whether the groups were homogenous at commencement of the programme. The results of the comparisons are presented in Table 1.

Table 1. *Comparison of MAT Pre-Test Mean Scores of E1 and C1*

Scale	Group	N	Mean	SD	df	t-value	p-value
Achievement (Max. Score = 25)	E1	52	8.58	4.74	106	.356	.723
	C1	56	8.29	3.74			

The pre-test Chemistry achievement mean score of E1 (M = 8.58, SD = 4.74) was similar to that of C1 (M = 8.29, SD = 3.74), and the difference between them was statistically insignificant, t (106) = 356, p = .723. The two groups were similar at the point of entry and therefore suitable for the study.

The effect of the treatment was established by conducting a mean gain analysis and comparing the post-test mean scores with pretest scores. Mean gain refers to the difference between pre-test and post-test mean scores of groups that participated in the study and gives an insight of the relative effects of treatment (Ngatia, 2019). Gain analysis was conducted using the pre-test and post-test mean scores of E1 and C1.

Table 2. *Comparison of Post-test and Pre-test scores on MAT for groups E1and C1*

Group	Pre-test		Post-test		Mean Gain
	Mean	SD	Mean	SD	
E1 (n = 52)	8.58	4.74	11.59	4.10	**3.01**
C1 (n = 56)	8.29	3.74	9.39	3.31	**1.11**

The pretest means scores of E1 (M = 8.58, SD = 4.74) and C1 (M = 8.29, SD = 3.74) were comparable. However, after treatment, E1 (M = 11.59, SD = 4.10) obtained a higher post-test mean score than C1 (M = 9.39, SD = 3.31). The gain of E1 (M = 3.01) was higher than that of C1 (M =1.11). This is suggests that MTI improves achievement better than CTM.

Additional analysis was conducted to find out if the difference between the mean gain of E1 and C1 was statistically significant using the t-test.

Table 3. *A t-test results comparing the Achievement in Chemistry mean gain of E1 and C1*

Group	N	Mean gain	SD	df	t-value	p-value
E1	52	3.01	1.95	106	5.283	.000
C1	56	1.11	1.79			

The difference between the mean gain of E1 (M = 3.01, SD = 1.95) and C1 (M = 1.11, SD = 1.79) was statistically significant, t (106) = 5.283, p = .000. These results imply that MTI is more effective in improving students' achievement in chemistry than CTM.

A comparison between achievement post-test mean scores of students exposed to MTI and those taught using CTM was also conducted. The mean score of E1, E2, C1 and C2 were M = 11.59, (SD = 4.10), M = 10.61 (SD = 3.01), M = 9.39 (SD = 3.31) and M = 8.98 (SD = 3.10) respectively. The One-Way Analysis of Variance (ANOVA) test was conducted to find out if the difference among the post-test means scores of E1, C1, E2 and C2 were statistically significant.

Table 4. *ANOVA of Post-test Scores on Mole Achievement test (MAT)*

Scale	Sum of Squares	Df	Mean Square	F-ratio	p-value
Between Groups	593.904	3	73.181	6.286	.000
Within Groups	3038.816	204	11.641		
Total	3632.720	207			

An examination of the results indicates that there was a statistically significant difference among the post-test mean scores of the groups, F (3, 204) = 6.286, p = .000. The significant difference called for additional analysis given that the results of the ANOVA test did not show which pair groups were significantly different. Difference between pair groups was determined using the Least Significant Difference (LSD) Post Hoc Multiple Comparisons test.

Table 5. *Chemistry posttest Achievement Pairwise Least Significant Differences*

Pair group	Mean Difference (I-J)	SD	p-value
E1 - E2	0.97	0.68	.153
E1 - C1	2.19	0.74	.004

E1 - C2	2.61	0.67	.000
E2 - C1	1.22	0.67	.019
E2 - C2	1.63	0.68	.018
C1 - C2	0.41	0.66	.533

The LSD test results indicate significant differences between pair groups E1 – C1 (p = .004), E1 – C2 (p = .000), E2- C1 (P=0.019) and E2 – C2 (p = .018). However, statistically insignificant differences were observed between groups E1 – E2 (p = .153) and C1 – C2 (p = .533). The pairwise comparisons show that the experimental groups performed better than the control groups.

Further analysis was conducted to find out whether there was a significant difference between Chemistry achievement post-test mean scores of the Experimental (E1 and E2 combined) and control (C1 and C2 combined) groups. The comparison was conducted using the independent sample t-test.

Table 6. *Independent sample t-test of MAT Post-test Experimental and Control Groups*

Group	N	Mean	SD	df	t-value	p-value
Experimental	101	11.11	3.63	206	4.047	.000
Control	107	9.20	3.20			

The t-test results reveal that the post-test mean score of the Experimental group (M = 11.11, SD = 3.63) was higher than that of the Control group (M = 9.20, SD = 3.20), The results also reveal that the difference between the two mean scores was statistically significant, t(206) = 4.047, p = .000.

The comparisons conducted using both the t-test and ANOVA showed statistically significant differences in favour of the Experimental groups. They do not support the paper hypothesis which stated that there is no statistically significant difference in students' achievement in Chemistry between those exposed to MTI and those taught using CTM.

The significance differences in favour of groups exposed to MTI support the notion that active and participatory teaching strategies promote students' engagement, application of practical skills and academic achievement. These findings support those of a study in Bhutan by Dupchu (2023) which revealed that integration of multimedia in teaching improved learning and academic achievement of secondary school students in Chemistry compared to those taught using conventional teaching methods. Ukamaka and Egolum's (2023) study in Nigeria also showed that students taught chemistry through multimedia integration were more interested in learning and performed better in the subject than those taught using CTM.

These findings of this study are in harmony with those of a study in Ethiopia by Yesgat et al. (2023) which revealed that integrating technology in Chemistry instruction enhanced retention and achievement. The study revealed that mean scores of students exposed to treatment were higher and significantly different from those taught using conventional methods. These findings also support those of Okero et al. (2021) which demonstrated that multimedia integration in teaching made the learning environment more conducive and engaging, enhanced cognitive processing, retention and students' academic achievement.

5. Conclusion and Recommendations

This inquiry concluded that use of MTI improves students' achievement in Chemistry better compared to CTM. This is due to MTI's ability to promote active learning by providing students with opportunities to engage multiple senses such as sight and hearing simultaneously. It also promotes peer learning, individual creativity, and innovation. MTI and other factors that have been associated with performance such instructional materials, effective instructional leadership and conducive school climates can thus be used improve achievement in Chemistry in secondary schools.

On the basis of the findings the paper recommends that school managers should provide their institutions with the necessary multimedia technology. This can be achieved through resource mobilization in collaboration with school Boards of Management, Parents' Association, Constituency Development Fund, County and National Governments. Chemistry teachers are also encouraged to incorporate MTI in teaching to improved students' learning and achievement. Further, regular training should be provided to Chemistry teachers as a way of ensuring they always possess the competencies required to integrate Multimedia Technology in teaching.

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