Research Article https://doi.org/10.12973/eu-jer.12.4.1697

European Journal of Educational Research
Volume 12, Issue 4, 1697 - 1708.
ISSN: 2165-8714
https://www.eu-jer.com/

Examining the Impact of Interactive Multimedia Instruction on the Performance of Secondary School Students in Biology in Dedza District, Malawi

Yamikani Willie Ntaila*
University of Rwanda, RWANDA / University of Malawi, MALAWI

Saidi Rumanzi Mbaraka
University of Rwanda, RWANDA

Received: October 7, 2022 ▪ Revised: January 28, 2023 ▪ Accepted: May 30, 2023

Abstract: This study examined the impact of teaching biology using interactive multimedia on the students' academic performance in biology at Community Day Secondary Schools (CDSS). This study was conducted in three secondary schools in the Dedza district, in the central region of Malawi. A pretest-posttest quasi-experimental approach was used in this investigation. A total number of 189 Form Four students were selected from the three schools. The schools were categorized into three groups, namely: (a) urban, (b) rural, and (c) control. The control group received instruction using a teacher-centered approach, while the experimental groups received instruction using interactive multimedia resources. The pretest was conducted for three weeks, after which the posttest was administered. One-way ANOVA in IBM-SPSS software was used to analyse the data. Our findings showed that multimedia instruction packages had a significant impact on student performance ($F(2, 188) = 126.557$, $p < .001$). Furthermore, after the intervention, the scores of the rural group and the urban group significantly varied ($p < .001$). Gender had a significant influence on the performance of students in biology ($F(1, 188) = 8.78$, $p = .003$). Therefore, the study concludes that the use of multimedia instructional packages helps learners understand abstract concepts in biology, and the study further recommends that multimedia instructional packages be used to teach hard-to-grasp concepts in biology in CDSS.

Keywords: *Interactive multimedia, multimedia instructional packages, multimedia learning, teacher-centered approach.*

To cite this article: Ntaila, Y. W., & Mbaraka, S. R. (2023). Examining the impact of interactive multimedia instruction on the performance of secondary school students in biology in Dedza district, Malawi. *European Journal of Educational Research*, *12*(4), 1697-1708. https://doi.org/10.12973/eu-jer.12.4.1697

Introduction

This is an age of technological advancements where science is the pillar of the prosperity of nations (Quarcoo-Nelson et al., 2012). Biology is one of those sciences that is essential for the development of countries in our contemporary world. Biology has long been a vital subject in science due to its applications in food sciences, health, ecosystem management, conservation, and agriculture (Akinbadewa, 2020). Therefore, the significance of the subject has resulted in increased awareness of the subject around the world. Sufficient biology education is required for students' overall future development (Ayittey et al., 2019). Biology is not only important for human growth, but it also has a significant impact on global socio-economic and political development (Ministry of Education, Science and Technology [MoEST], 2013). However, despite its general importance, the performance of secondary school students in biology has been subpar (Gambari et al., 2014). Various studies have reported low student performance in internal biology examinations (Chinna & Dada, 2013). Teachers' teaching approaches have been blamed for the continued poor academic success in biology (Yusuf & Afolabi, 2010). The current traditional lecture method of teaching renders learners passive and promotes memorization, which ultimately causes learners to become bored with learning (Garraway-Lashley, 2014). A technology-assisted instructional system would be essential for ensuring effective learning in 21st century education (Van Laar et al., 2020). Technological advancements such as multimedia-assisted teaching packages may be used in biology classes in conjunction with traditional methods of instruction to help students to learn more effectively (Vinayak et al., 2009). Text, audio, and video are some of the types of media that may be used to represent and show information using multimedia technology (Guan et al., 2018).

* **Corresponding author:**
Yamikani Willie Ntaila, ACEITLMS, University of Rwanda, College of Education, Rwanda/ University of Malawi, School of Natural and Applied Sciences, Department of Biological Sciences, Malawi. ✉ ntailay13@gmail.com

© 2023 The Author(s). **Open Access** - This article is under the CC BY license (https://creativecommons.org/licenses/by/4.0/).

Multimedia is multisensory since it involves several senses in the audience at the same time (Gilakjani, 2012). According to Akinbadewa (2020), multimedia educational packages considerably improve students' understanding of biology subjects as compared to the traditional approach. Multimedia learning assists learners in comprehending complex concepts and can also encourage cooperative learning, critical thinking, and problem-solving skills (Clements & Sarama, 2003; Stephen et al*.,* 2008). Similarly, Ayittey et al. (2019) found that multimedia instruction is better suited to teaching abstract topics in biology. Countries in sub-Saharan Africa (SSA) have enacted information and communications technology (ICT) policies to promote the utilization of ICT in education to improve student interaction and performance. The incorporation of multimedia in teaching and learning in SSA largely depends on the level of ICT development. Multimedia teaching and learning cannot materialize without ICT resources. Countries like South Africa have taken greater strides in using technology in teaching (Burns & Santally, 2019). Most SSA countries suffer from a lack of ICT resources, lack of well-trained teachers, and poor funding and infrastructure. As is the case with many countries in SSA, Malawi is faced with constraints in financial resources, a lack of ICT infrastructure and resources, and also unreliable and unstable power (Isaacs, 2007). Many schools in Malawi do not have computers or computer laboratories, and a majority of the schools in rural areas are not electrified. This makes the dream of incorporating ICT into teaching and learning a far-reaching one. Although some schools in most urban areas have computers and are well electrified, the computers are not fully utilized for teaching and learning but are rather used for administrative purposes and computer studies as a subject (Isaacs, 2007).

Although the incorporation of technology in teaching remains a development that is in its infancy in many SSA countries, including Malawi, multiple external representations are an effective approach to promoting learning and boosting comprehension in a multimedia learning environment (Schnotz & Lowe, 2003). The interesting effects of multimedia continue to compel researchers to conduct research both within and outside of the classroom, necessitating the need for this investigation.

Education System in Malawi

The formal education system in Malawi comprises three levels, namely primary, secondary, and higher education. Primary schools last for eight years, and upon completion, a learner gets a primary school leaving certificate (PSLCE) (Zeitlyn et al., 2015). Students who pass PSLCE are admitted into secondary schools. Secondary school education lasts for four years, and learners are awarded the Malawi School Certificate of Education (MSCE) upon completion. Higher education varies from two years for a certificate to four or five years for a bachelor's degree (Zeitlyn et al., 2015).

Typology of Secondary Schools

Secondary schools in Malawi are categorized into two main groups, namely public and private schools. Private schools are schools that are run by independent business owners without government funding. They are divided into two categories: those that follow the Malawi curriculum and those that cater mostly to international students and use the European curriculum (Zeitlyn et al., 2015). Public secondary schools are categorized into three groups, namely: conventional secondary schools (CSS), community day secondary schools (CDSS), and open day secondary schools (ODSS). CSSs are government-sponsored schools that enjoy the greatest access to both human and material resources for education (Chimombo et al., 2014). Students who perform well in their primary school leaving certificate examinations are admitted into these schools. This category of schools outperforms all other school types in national examinations (Zeitlyn et al., 2015). CDSS are the public schools that are the cheapest form of secondary schooling in Malawi (Chimombo et al., 2014). They typically have inadequate funding, unqualified teachers, a subpar learning environment, and inadequate teaching and learning resources and apparatus (World Bank, 2010). These schools are characterized by poor performance, and very few of their students are admitted to public universities (Zeitlyn et al., 2015). ODSS is an alternative means of delivering secondary education (Chimombo et al., 2014). They operate on the existing structures of public secondary schools in the afternoon hours after the others have knocked off (Zeitlyn et al., 2015). These schools provide extra revenue for teachers (Chimombo et al., 2014).

Statement of the Research Problem

Malawi's educational system follows the 8-4-4 pattern. Learners sit for the Primary School Leaving Certificate Examination at the end of their eighth year of primary school (World Bank, 2010). Some students are accepted into secondary schools. Secondary school education in Malawi lasts four years, with two national examinations. The Junior Certificate Examination is administered in year two, and the MSCE in year four (MoEST, 2019). Passing the MSCE is very important because the performance determines whether students will be selected to pursue tertiary education or not (MoEST, 2019). However, as evidenced by examiner reports and related studies, there has been a persistent decline in science performance at both the JCE and MSCE levels (Maseko & Khoza, 2021). Biology being one of the sciences, it is not an exception to this perennial decline in performance (Malawi National Examinations Board [MNEB], 2019). Just as in other science subjects, biology has a higher percentage of students failing or receiving poor grades. However, the examination results for students in the CDSS for science, including biology, have been much worse since the establishment of these CDSS than in the CSS. In addition to a lack of resources for teaching and learning, poor

infrastructure, and insufficient teachers in most of the CDSS, the poor performance in national examinations has also been attributed to an ineffective teaching method that are mostly teacher centered (Chibwana & Rajamehala, 2022). The teacher-centered approach is the tradition teaching strategy where the teacher controls the learning experience and passes on the required knowledge to the students, which they receive passively (Serin, 2018). The student's role in this approach is to pay attention to the teachers and pick up knowledge from them as they teach. This teaching approach encourages rote learning, making it ineffective for teaching abstract and difficult topics such as cell biology, nervous coordination, genetics, etc. (Çimer, 2012). To achieve the admirable objectives of good academic performance by students at Community Day Secondary School, new approaches based on technology integration strategies are desperately needed because existing methods of teaching science are failing to enable students to develop problem-solving skills, as well as critical and logical thinking (Shah & Khan, 2015). Akinbadewa (2020) suggested that the multimedia teaching approach can help to improve the performance of students in biology in secondary schools from its current status. Multimedia resources are viewed as a crucial part of our teaching strategies and assist in the development of knowledge of successful teaching techniques in a student-centered setting (Choiriyah et al., 2022). Students can learn more effectively from well-designed multimedia resources that combine words and images than they can from more conventional forms of instruction that rely just on words (Choiriyah et al., 2022; Plowman & Stephen, 2005). Therefore, in light of the foregoing, this study was carried out to determine the impact of multimedia instruction on students' academic performance in biology at CDSS in Dedza, Malawi.

The Objective of the Study

The study has the following specific objectives;

1. To determine the effects of the multimedia teaching approach on students' academic outcomes over the traditional method in Dedza district, Malawi.
2. To determine the difference in academic outcomes of students taught using the multimedia approach in urban and rural schools in Dedza district, Malawi.
3. To determine the effect of the multimedia teaching approach on the academic outcome of different genders in Dedza district, Malawi.

Significance of the Research

Improving biology results in secondary schools is a great task in Malawi. A current challenge of poor academic performance in the subject of biology, for which no practical solutions have yet been discovered, has triggered the need for this study. This research aims to help in this regard by looking into alternative teaching and learning methods, particularly for topics that have been difficult for both teachers and students, such as genetics, coordination, the nervous system, etc. The study provides practical solutions for improving poor academic performance in biology, which will benefit CDSS students who are already struggling with decimal performance. Therefore, the results of this study are fundamental to curriculum and policy development, teaching and learning, and secondary school administration.

Literature Review

Theoretical Framework

This study was based on the cognitive theory of multimedia learning, which tries to describe how learning happens using multimedia tools. The theory examines how human beings process information in working and long-term memory to ensure that knowledge presented in a multimedia environment leads to a meaningful learning experience (Mayer, 2001; Toh et al., 2010). The cognitive theory of multimedia learning arose from studies of text and illustrations as well as experiments, which found that illustrations with integrated text improved learning effectiveness (Mayer, 2009). The cognitive theory of multimedia learning (CTML) assumes that pupils attempt to form logical connections between words and pictures to have a deeper understanding than they can with only words or pictures (Mayer, 2009). The hypothesis maintains that using animation without narrative or speech without animation treatments is less effective than using narration and animations together. One of the fundamental goals of multimedia learning, according to cognitive science, is to enable the learner to form a cohesive mental image from the supplied content. The learner's task as an active participant is to make sense of the material delivered and eventually create new information (Sorden, 2012). This theory is built on three assumptions. The first assumption is the dual-channel processing hypothesis, which postulates that humans have two independent channels for processing auditory and visual information (Mayer, 2007; Rudolph, 2017). It stresses two channels of information: verbal and nonverbal. According to Henry (2011), the verbal and nonverbal processing channels are functionally independent but linked. Everything we see is processed through the visual channel, and everything we hear is processed through the verbal channel. The second assumption is the limited capacity theory, which postulates that the amount of data or load that each person can handle simultaneously in each of the dual channels is constrained (Clark & Mayer, 2008; Toh et al., 2010). Van Merrienboer and Sweller (2005) contend that we are continuously bombarded with large volumes of material, making it difficult to recall anything. Therefore, since the ability

to process information in the verbal and visual channels is constrained, teachers must prevent their students from experiencing cognitive overload (Van Merrienboer & Sweller, 2005). The third assumption is the active processing hypothesis, which postulates that individuals actively use cognitive processing to create mental images of their experiences (Henry, 2011). Mayer (2007, 2008) opines that individuals are viewed as actively processing and interacting with incoming information. Therefore, the cognitive theory of multimedia learning and its assumptions are founded on constructivism's learning theory, which views learning as an active, contextualized process of knowledge construction rather than knowledge acquisition (Mogonea & Mogonea, 2014). In this study, the major research question focuses on whether multimedia teaching methods enhance student academic achievement in biology.

Methodology

Research Philosophy

This study was based on the positivistic research paradigm. According to this theory, only factual knowledge acquired from observation or the senses, including measurement, is regarded as authentic knowledge (Collins, 2010). Positivism is based on quantifiable observations that can be analyzed statistically. Determinism, mechanism, method, and empiricism are the four aspects of science that positivism is built on (Cohen et al., 2000). Positivism is based on the empiricist belief that knowledge is gained from human experience. Under this researcher paradigm, the researcher is expected to observe the occurrence of a particular phenomenon under study and give a generalized conclusion of what may happen elsewhere (Kivunja & Kuyini, 2017). As a result, positivism was selected as the study's research philosophy due to the scientific aspect of the study, which entailed experimentation to examine the findings and provide answers to questions.

Research Design

The study used a pretest-posttest nonequivalent group design. This is the quasi-experimental design where the experimental group was given a pre-test, an intervention, and then a post-test. At the same time, a non-equivalent control group was given a pre-test with no intervention, and then a post-test was administered. This was chosen because the groups were to be given a pre-test, and a post-test and also because it was not possible to randomize individuals into experimental and control groups during the study.

Target Population, Study Sample, and Sampling Techniques

The target population of the study was Form Four students taking biology, who were drawn from three CDSS in Dedza District in the Central Western Education Division.

The study used a sample size of 189 Form Four secondary school students in the Dedza district of Malawi. The sample comprised an experimental urban group, an experimental rural group, and one control group. The control setup consisted of 60 participants, the experimental rural setup consisted of 66 participants, and the experimental urban setup consisted of 63 participants. The general distribution of the participants is shown in Figure 1.

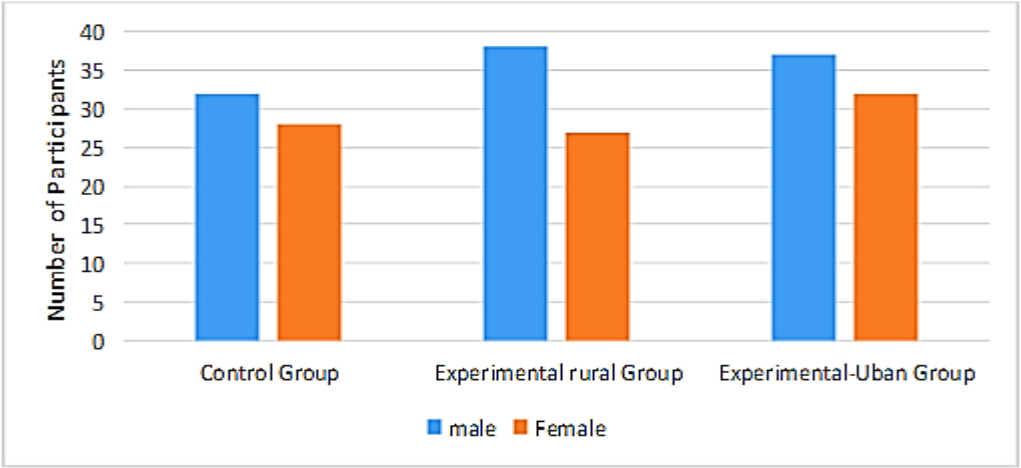

Figure 1. The Number of Participants in the Research Study

Teachers Training

Teachers with either diploma or bachelor's degree levels were selected from the schools and given the necessary orientation and training on using multimedia materials in teaching the topic of the human nervous system and the administration of the instruments. This was done in the span of a week. The teachers were familiarized with the

courseware packages. The courseware package was downloaded from the internet, and the power point slides were prepared by the researcher.

Development of Tests

The Biology Assessment Test (BAT) consisted of 20 objectives that were developed by the researcher. The tests included a pretest and a post-test. The questions were structured according to Bloom's taxonomy. The contents of the assessment were the same, but what differed was the wording and the position that the item occupied in the pre-test and post-test.

Reliability and Validity of Test Instruments

The reliability of the test was determined using data from the pilot study, which consisted of 40 students. Cronbach's alpha was used to evaluate the internal consistency reliability. The coefficient of Cronbach's alpha was 0.84. This shows that the test instrument was 84% reliable. This study used content validity for the test. The test items were tested and validated by peer review, whereby the items were given to the selected experts and teachers who are the examiners of biology for the Malawi National Examination Board. Comments from the reviewers were taken into consideration, and necessary modifications were made.

Intervention

Each of the two experimental groups comprised of 66 and 63 students, respectively. One experimental group was from an urban school, while the other was from a school in the rural part of the district. These two groups were taught using interactive multimedia.

The courseware package and videos for the topic of human nervous systems were downloaded from the Internet, while the PowerPoint slides were designed and prepared by the researcher. The multimedia packages that included the simulation packages, on-screen text, video, still images, and animations for the topic of human nervous systems were provided by the teacher to the students. The learners explored and interacted with the content, which was complemented by the teacher, who guided the students as they interacted with the multimedia packages and also gave explanations on the videos, slides, simulation animations, and slides concurrently. This was done for three weeks.

The control group consisted of 60 students who received teacher centered instruction. The teacher delivered the lessons, and the learners listened to the teacher. They were not engaged with any interactive multimedia resources.

Data Collection

Data for academic performance was collected through the non-equivalent group design pretest-posttest procedure within the space of four weeks. In the first week before the intervention stage, the Biology Assessment Test was administered as a pre-test to both study groups. This test was given to test for the homogeneity of the study groups. Immediately after three weeks of learning, a biology assessment test was given to evaluate the students' learning outcomes and academic achievement.

Results and Data Analysis Methods

The collected data was analyzed based on the formulated research questions. The data were tested for normality and were found to be normally distributed. Therefore, the data were analysed using the parametric test technique of a one-way ANOVA in IBM-SPSS software for inferential statistics. The inferential statistics were complemented by descriptive statistics that were used to describe and compare sets of data from the study.

During the analysis, the scripts of students who sat for the pretest and missed the posttest and those who sat for the posttest but had missed the pretests were never considered. Furthermore, the scripts of students who had missed more than two lessons were removed and never considered for the analysis.

Findings/ Results

Test of the Homogeneity of the Study Groups

The data from the pre-test were analysed to determine whether the groups did not significantly vary from each other. Table 1 shows that the learners in the urban group obtained a mean score of 17.91 (SD = 9.51). The rural group obtained a mean score of 19.83 (SD = 8.15) and the control group obtained a mean score of 16.49 (SD = 9.55). The results indicate that the rural group had a higher mean score than the other groups.

Table 1. Comparison of Mean Scores of Pre-Test Between Learners Taught With Multimedia Materials in Urban Group, Rural Group and Control Group

Name of group	Number	Mean	Std. Deviation	Std. Error Mean
Urban Group	68	17.91	9.51	1.15
Rural group	72	19.83	8.15	0.96
Control group	65	16.49	9.55	1.19

The findings in Table 2 show that mean scores of the groups did not significantly vary before the intervention; F (2, 205) = 2.347, p = .098.

Table 2. Difference in Mean Scores of Pre-Test Among the Control Group, Urban Group and Rural Group Before the Intervention

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	386.470	2	193.235	2.347	.098
Within Groups	16713.724	203	82.334		
Total	17100.194	205			

Effects of Multimedia Instructional Packages on the Academic Outcome of Students

The study compared the academic achievement of students in terms of mean scores between learners taught using multimedia instructional packages (urban and rural groups) and those in the control group exposed to the teacher-centered approach. Our results show that the urban group obtained a mean score of 67.17 (SD = 10.88), the rural group obtained a mean score of 57.36 (SD = 7.89), and the control group obtained a mean score of 42.10 (SD = 7.16) (Table 3). The results show that the urban group has a higher mean score than the rural group, with a mean score difference of 9.81. The control group has the lowest mean score among the three samples. There is a mean score difference of 25.07 between the urban group and the control group. The mean score difference between the rural group and control group is 15.26. Table 3 below shows the results.

Table 3. Comparison of Mean Score on Post-Test Scores Between Experimental Groups and Control Group.

Name of group	Number	Mean	Std. Deviation	Std. Error Mean
Urban Group	63	67.17	10.88	.92
Rural group	66	57.36	7.89	.97
Control group	60	42.10	7.16	.92

The results indicate that the mean scores of students among the study groups significantly varied after the intervention, F (2, 188) = 126.557, p < .001. Therefore, there is a discernible difference in achievement mean scores between students receiving multimedia instruction and those receiving traditional instruction. This shows that the intervention had a substantial impact on the academic outcome of students in biology. Table 4 below shows the results.

Table 4. Effect of Treatment on Students' Academic Performance in Biology for the Control Group, Urban Group, and Rural Group in Dedza District

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	19573.782	2	9786.891	126.557	.000
Within Groups	14383.752	186	77.332		
Total	33957.534	188			

A pairwise comparison was carried out to find the existence of a significant difference. The data in Table 5 show that the mean scores of the control group and urban group significantly varied (p < .001). There is also a significant variation in mean scores between the rural and control groups (p < .001). Furthermore, the mean scores of the urban group and the rural group significantly varied (p < .001). Table 5 below shows the results.

Table 5. Pairwise Comparison to Determine Where the Significant Difference Exists

Dependent Variable: Scores Tukey HSD						
(I) Group	**(J) Group**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Control	Rural	-15.264*	1.569	.000	-18.97	-11.56
	Urban	-25.075*	1.569	.000	-28.82	-21.33
Rural	Control	15.264*	1.569	.000	11.56	18.97
	Urban	-9.811*	1.569	.000	-13.47	-6.15
Urban	Control	25.075*	1.586	.000	21.33	28.82
	Rural	9.811*	1.549	.000	21.33	13.47

*. The mean difference is significant at the .05 level.

Comparison of the Mean Scores Among the Study Groups Before and After Intervention

The study compared the mean scores of the study groups before and after the intervention. The students' mean scores after the intervention were higher than before the treatment. The results are as presented in Figure 2 below.

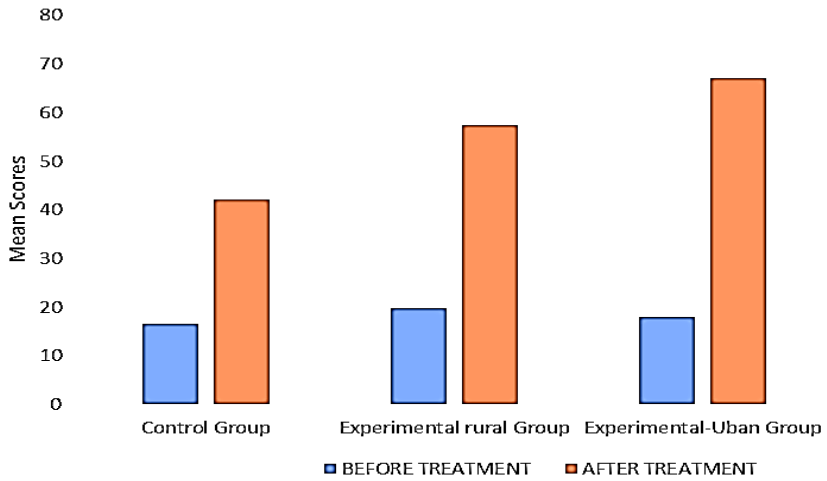

Figure 2. Mean Scores of Students in the Study Groups Before and After Intervention

Effects of Multimedia Instructional Packages on the Academic Outcome of Students in Urban and Rural CDSS

The academic achievement of students in the rural group and urban group was compared after treatment. The results show that both the rural group and urban group improved their performance in the posttest. However, the urban group has a higher mean gain score (49.26) than the rural group (37.88). The results of Table 5 above elucidate that the scores of the rural group and the urban group significantly varied ($p < .001$). Table 6 shows the students' mean gain scores after being taught using multimedia instructional materials in urban and rural schools.

Table 6. Mean Gain Scores of Students Taught Using Multimedia Instructional Materials in Urban and Rural Schools in the Dedza District of Malawi.

Group	**Pre-Test Score**	**Post-Test Score**	**Mean Gain Score**
Experimental Urban	17.91	67.17	49.26
Experimental Rural	19.83	57.36	37.88

Effects of Multimedia Instructional Packages on the Academic Outcome of Students According to Gender

The study determined mean scores between male and female learners exposed to the multimedia instructional packages and those exposed to the teacher-centered approach in selected schools in the Dedza district of Malawi. The results show that in the control group, male students had a higher mean gain score (27.09) than the female students (24.16). However, in the urban group, the male students had a lower mean gain score (36.74) than the female students (38.96). Lastly, in the urban group, the male students had a mean gain score that was greater (50.91) than the female students' mean gain score (46.02). Table 7 below shows the results.

Table 7. Mean Gain Scores of Male and Female Students for the Control Group, Urban Group and the Rural Group.

Group	Gender	Pre-Test Score	Post-Test Score	Mean Gain Score
Control	Male	17.58	44.67	27.09
	Female	15.57	39.53	24.16
Experimental rural	Male	20.74	57.08	36.74
	Female	18.82	57.78	38.96
Experimental urban	Male	18.59	69.50	50.91
	Female	17.12	63.13	46.02

The mean scores between female and male students varied significantly (F (1, 188) = 8.78, p = .003). Table 8 below shows the results.

Table 8. Effects of Intervention on Students' Learning Outcome According to Gender

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1522.869	1	1522.869	8.780	.003
Within Groups	32434.666	187	173.447		
Total	33957.534	188			

The follow-up analysis was carried out to establish the existence of a difference in the mean scores by gender. In the urban group, the mean scores of male and female students varied significantly (F (1, 62) = 5.362, p = .024). The female learners performed better than the male learners. The mean scores of male and female students in the rural group did not significantly vary (F (1, 65) = 0.125, p = .725). Furthermore, results show that the mean scores of female and male students in the control group significantly varied (F (1, 59) = 8.716, p = .005). Tables 9, 10, and 11 respectively show the results.

Table 9. Effect of Intervention on Students' Academic Outcome of Students on Gender in Urban Group.

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	592.471	1	592.471	5.362	.024
Within Groups	6740.609	61	110.502		
Total	7333.079	62			

Table 10. Effect of Intervention on Students' Academic Outcome of Students Based on Gender in an Experimental Rural Group.

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.837	1	7.837	.125	.725
Within Groups	4017.436	64	62.772		
Total	4025.273	65			

Table 11. Effect of Intervention on Students' Academic Outcome of Students Based on Gender in the Control Group

Scores	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	395.267	1	395.267	8.716	.005
Within Groups	2630.133	58	45.347		
Total	3025.400	59			

Discussion

The results of the pretests show that the mean scores for the rural group, urban group, and the control group did not significantly vary from one another. This shows that both study groups were homogenous before they were exposed to the intervention, although they had slight differences in their mean scores. The post-intervention achievement mean scores varied significantly between students taught using multimedia instruction materials (experimental groups) and those taught using the traditional approach (control groups) in Malawi's Dedza district. This indicates that the intervention improved the academic performance of the students in biology. The findings concur with the results of Ayittey et al. (2019), which looked at how biology students in senior high school performed after receiving multimedia instruction. The findings also concur with the findings of Adegoke (2010), which examined the effects of multimedia instruction in physics. Additionally, John et al. (2018) discovered that students who learned biology using a multimedia instructional strategy outperformed those who learned the subject through teacher-centered methods. Similar findings were made by Kareem (2018), who discovered that students receiving multimedia-assisted instruction outperformed their peers receiving conventional instruction. However, the study by Stuckey-Mickell and Stuckey-Danner (2007) that

compared virtual and face-to-face labs for biology revealed that 87% of the students thought that face-to-face labs were more effective than the virtual labs.

The results also show that the academic outcomes of learners taught using multimedia instructional packages in urban and rural schools in the Dedza district of Malawi significantly varied. This could be a result of differences in exposure to technologies between students found in urban areas and those in rural areas. In urban areas, students are better exposed to ICT and have more access to technologies than students in rural areas due to the technological divide that exists (*United Nations International Children's Emergency Fund* [UNICEF], 2020). Students in rural areas do not have personal computers or access to the internet. As a result, they are not familiar with using them for educational purposes. On the other hand, most of the students in urban areas own their own computers, and they also have an internet connection. This gives them a comparative advantage in interacting with the multimedia materials and grasping the concepts (Kumar & Kumara, 2018). Olutola (2016) suggests that the significant performance gap between urban and rural students may be caused by differences in exposure to social amenities and educational resources between students in urban and rural areas. Students in urban areas have access to different social amenities and educational resources, which help them outperform students from rural locations.

The findings show that mean scores between male and female pupils who received multimedia instruction and those who were taught using a traditional teacher centered approach vary significantly. In an experimental urban group where students were taught using multimedia instructional packages, male students had a higher post-test mean score gain than female students. This may be due to gender stereotypes that prescribe gender roles to boys and girls. Societal norms expect boys to be exposed to technological gadgets, whereas females are expected to learn virtue and provide care (Clayton et al., 2009). As a result, when it comes to using technologies, female students exhibit greater fear and lower levels of competence than male students (Kukulska-Hulme & Traxler, 2007). This finding is in tandem with the findings of Heo and Toomey (2020), who found that mean scores of undergraduate students in relation to gender significantly vary. Male students performed significantly better than female students. The findings are also in tandem with the findings by Raheem (2012), who discovered that male students performed better than female students in the fields of science, math, and the social sciences. However, in the experimental rural group, the female students outperformed the male students. This finding concurs with the findings by Olutola (2016), who also found that academic performance in relation to gender in the WASSCE multiple-choice biology test significantly varied, with female students performing significantly better than males. The mean score by gender in the rural group did not significantly vary. This agrees with the findings of the study by Ayittey et al. (2019), which found no significant variation in gender. Furthermore, in the study conducted by Akinbadewa (2020), male and female students did not significantly vary when exposed to interactive multimedia.

Conclusion

In conclusion, the study's findings, which looked at how multimedia instruction affected students' academic performance in biology, showed interactive multimedia helps improve the academic outcome of students in biology. Urban students perform better in comparison to their rural counterparts when exposed to the teaching and learning of the human nervous system through the use of multimedia resources. Gender affects the academic outcomes of students taught using a multimedia method versus those taught using a traditional approach.

Recommendations

Teachers should expose learners to multimedia resources when teaching hard-to-grasp topics to enable students in CDSS to grasp the concepts. The government should ensure that CDSS have computers and access to the internet to enable teachers to teach the learners using multimedia resources. More Telecentres must be built in rural areas and get resourced so that students in rural areas who do not usually have personal computers can use them and become acquainted with computers. Those who have similar interest in reaching this area should conduct a similar study with a larger sample size than was used in this study to obtain more comprehensive findings. Furthermore, a study should also be conducted to determine the attitude of biology teachers towards the use of multimedia instructional packages in teaching lessons in Community Day Secondary Schools.

Limitations

This study is limited to examining the impact of interactive multimedia on the academic performance of students in biology. In addition, this study is also limited to students in CDSS. Other similar studies can be carried out on students in private and conventional public secondary schools.

Acknowledgements

The researcher wishes to express sincere gratitude to everyone who participated in the study and to those who supported the study both in money and in kind.

Funding

This research was funded by African Centre of Excellence in Innovative Teaching and Learning Mathematics and Science (ACEITLMS).

Authorship Contribution Statement

Ntaila: Conceptualization, design, data acquisition, analysis and interpretation, writing of manuscript. Mbaraka: Editing/critical reviewing, supervising and giving final approval.

References

Adegoke, B. A. (2010). IIntegración de animaciones, narraciones y textos para la mejora del aprendizaje en Física [Integrating animations, narrations and textual information for improving Physics learning]. *Electronic Journal of Research in Educational Psychology/Revista electrónica de Investigación Psicoeducativa y Psicopedagógica, 8*(2), 725-748. https://doi.org/10.25115/ejrep.v8i21.1391

Akinbadewa, B. O. (2020). The effect of multimedia instructional packages on students' academic achievement in biology. *International Online Journal of Education and Teaching*, *7*(4), 1266-1281. https://rb.gy/ngvnce

Ayittey, A., Arthur-Nyarko, E., & Onuman, F. (2019). Impact of multimedia instruction in biology on senior high school students' achievement. *Computer Science and Information Technology*, *7*(5), 162-173. https://doi.org/10.13189/csit.2019.070502

Burns, M., & Santally, M. I. (2019). *Information and communications technologies and secondary education in sub-Saharan Africa: Policies, practices, trends and recommendations*. Mastercard Foundation. https://doi.org/10.15868/socialsector.36828

Chibwana, B., & Rajamehala, M. (2022). Factors affecting performance of learners in physics and biology subjects in community day secondary schools. *International Journal of Novel Research and Development, 7*(9), 1665-1673. https://bit.ly/3JSZPTQ

Chimombo, J., Meke, E., Zeitlyn, B., & Lewin, K. M. (2014). *Increasing access to secondary school education in Malawi: Does private schooling deliver on its promises*? (Working Paper No. 61). Privatisation in Education Research Initiative. https://rb.gy/5lpu67

Chinna, N. C., & Dada, M. G. (2013). Effects of developed electronic instructional medium on students' achievement in biology. *Journal of Education and Learning*, *2*(2), 1-7. https://doi.org/10.5539/jel.v2n2p1

Choiriyah, Mayuni, I., & Dhieni, N. (2022). The effectiveness of multimedia learning for distance education toward early childhood critical thinking during the COVID-19 pandemic. *European Journal of Educational Research*, *11*(3), 1553-1568. https://doi.org/10.12973/eu-jer.11.3.1555

Çimer, A. (2012). What makes biology learning difficult and effective: Students' views. *Educational Research and Reviews*, *7*(3), 61 -71. https://rb.gy/gglzcs

Clark, R. C., & Mayer, R. E. (2008). Learning by viewing versus learning by doing: Evidence-based guidelines for principled learning environments. *Performance Improvement*, *47*(9), 5-13. https://doi.org/10.1002/pfi.20028

Clayton, K. L., von Hellens, L. A., & Nielsen, S. H. (2009, May). Gender stereotypes prevail in ICT: A research review. In N. Power (Eds.), *Proceedings of the Special Interest Group on Management Information System's 47th Annual Conference on Computer Personnel Research* (pp. 153-158). Association for Computing Machinery. https://doi.org/10.1145/1542130.1542160

Clements, D. H., & Sarama, J. (2003). Young children and technology: What does the research say? *YC Young Children*, *58*(6), 34-40. https://www.jstor.org/stable/42729004

Cohen, L., Manion, L., & Morrison, K. (2000). *Research methods in education* (5th ed.). Routledge. https://doi.org/10.4324/9780203224342

Collins, H. (2010). *Creative research: The theory and practice for the creative industries*. AVA.

Gambari, I. A., Yaki, A. A., Gana, E. S., & Ughovwa, Q. E. (2014). Improving secondary school students' achievement and retention in biology through video-based multimedia instruction. *InSight: A Journal of Scholarly Teaching*, *9*, 78-91. https://doi.org/10.46504/09201407ga

Garraway-Lashley, Y. (2014). Integrating computer technology in the teaching of Biology. *International Journal of Biology Education*, *3*(2), 13-30. https://rb.gy/1wevjq

Gilakjani, A. P. (2012). Visual, auditory, kinaesthetic learning styles and their impacts on English language teaching. *Journal of Studies in Education. Journal of Studies in Education*, *2*(1), 104-113. https://doi.org/10.5296/jse.v2i1.1007

Guan, N., Song, J., & Li, D. (2018). On the advantages of computer multimedia-aided English teaching. *Procedia Computer Science*, *131*, 727-732. https://doi.org/10.1016/j.procs.2018.04.317

Henry, B. A. (2011). *Multimedia learning applying multimedia learning to social and cognitive load theory*. Academia. https://rb.gy/ttlksh

Heo, M., & Toomey, N. (2020). Learning with multimedia: The effects of gender, type of multimedia learning resources, and spatial ability. *Computers & Education*, *146,* Article 103747. https://doi.org/10.1016/j.compedu.2019.103747

Isaacs, S. (2007). *Survey of ICT and education in Africa: Malawi Country Report*. InfoDev ICT and Education Series. https://rb.gy/qgdulg

John, S., Musa, A. A., & Waziri, K. (2018). Multimedia instructional strategy and secondary school students' academic achievement in biology. *Journal of Scientific and Engineering Research*, *5*(2), 73-80. https://rb.gy/lzbvxx

Kareem, A. A. (2018). The use of multimedia in teaching biology and its impact on students' learning outcomes*. The Eurasia Proceedings of Educational and Social Sciences, 9*, 157-165. https://rb.gy/qwukzc

Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education*, *6*(5), 26-41. https://doi.org/10.5430/ijhe.v6n5p26

Kukulska-Hulme, A., & Traxler, J. (2007). Designing for mobile and wireless learning. In H. Beetham & R. Sharpe (Eds.), *Rethinking pedagogy for a digital age* (pp. 200-212). Routledge. https://doi.org/10.4324/9780203961681

Kumar, B. T. S., & Kumara, S. U. S. (2018). The digital divide among the rural and urban students: An exploration. *South Asian Journal of Participative Development*, *18*(2), 160-167.

Malawi National Examinations Board. (2019). *Chief examiners' reports Malawi Senior Certificate Biology Examinations*. Unpublished annual report.

Maseko, B., & Khoza, H. C. (2021). Exploring the influence of science teaching orientations on teacher professional knowledge domains: A case of five Malawian teachers. *Eurasia Journal of Mathematics, Science and Technology Education*, *17*(12), Article em2041. https://doi.org/10.29333/ejmste/11333

Mayer, R. E. (2001). *Multimedia learning*. Cambridge University Press. https://doi.org/10.1017/CBO9781139164603

Mayer, R. E. (2007). Research-based guidelines for multimedia instruction. *Reviews of Human Factors and Ergonomics*, *3*(1), 127–147. https://doi.org/10.1518/155723408X299861

Mayer, R. E. (2008). Applying the science of learning: Evidence-based principles for the design of multimedia instruction. *American Psychologist, 63*(8), 760-769. https://doi.org/10.1037/0003-066X.63.8.760

Mayer, R. E. (2009). *Multimedia learning.* Cambridge University Press. https://doi.org/10.1017/CBO9780511811678

Ministry of Education, Science and Technology. (2013). *Republic of Malawi syllabus for biology forms 3 and 4*. SCRIPD. https://bit.ly/447FlPs

Ministry of Education, Science and Technology. (2019). *Malawi education sector analysis*. Malawi Government. https://rb.gy/tvaxbd

Mogonea, F.-R., & Mogonea, F. (2014). The constructivist teaching and the optimization of learning through cognitive maps*. Procedia - Social and Behavioral Sciences*, *128,* 164–168. https://doi.org/10.1016/j.sbspro.2014.03.137

Olutola, A. T. (2016). School location and gender as predictors of students' performance in WASSCE multiple choice test in biology. *Liceo Journal of Higher Education Research*, *12*(1), 1-16. https://doi.org/10.7828/ljher.v12i1.960

Plowman, L., & Stephen, C. (2005). Children, play, and computers in pre-school education. *British Journal of Educational Technology*, *36*(2), 145-157. https://doi.org/10.1111/j.1467-8535.2005.00449.x

Quarcoo-Nelson, R., Buabeng, I., & Osafo, D. K. (2012). Impact of audio-visual aids on senior high school students' achievement in physics. *International Journal of Physics and Chemistry Education*, *4*(1), 46–54. https://rb.gy/uez69i

Raheem, B. O. A. (2012). The influence of gender on secondary school students' academic performance in South-West, Nigeria. *Journal of Social Sciences, 31*(1), 93-98. https://doi.org/10.1080/09718923.2012.11893018

Rudolph, M. (2017). Cognitive theory of multimedia learning. *Journal of Online Higher Education*, *1*(2), 1-15. https://rb.gy/hngpic

Schnotz, W., & Lowe, R. (2003). External and internal representations in multimedia learning. *Learning and Instruction, 13*(2), 117–123. https://doi.org/10.1016/S0959-4752(02)00015-4

Serin, H. (2018). A comparison of teacher-centered and student-centered approaches in educational settings. *International Journal of Social Sciences & Educational Studies*, *5*(1), 164-167. https://doi.org/10.23918/ijsses.v5i1p164

Shah, I., & Khan, M. (2015). Impact of multimedia-aided teaching on students' academic achievement and attitude at elementary level. *US-China Education Review A, 5*(5), 349-360. https://doi.org/10.17265/2161-623X/2015.05A.006

Sorden, S. D. (2012). The cognitive theory of multimedia learning. In B. J. Irby, G. Brown, R. Lara-Aiecio, & S. Jackson (Eds.), *The handbook of educational theories* (pp. 155-167). Information Age Publishing Inc. https://rb.gy/siiz3c

Stephen, C., McPake, J., Plowman, L., & Berch-Heyman, S. (2008). Learning from the children: Exploring preschool children's encounters with ICT at home. *Journal of Early Childhood Research*, *6*(2), 99-117. https://doi.org/10.1177/1476718X08088673

Stuckey-Mickell, T. A., & Stuckey-Danner, B. D. (2007). Virtual labs in the online biology course: Student perceptions of effectiveness and usability. *MERLOT Journal of Online Learning and Teaching*, *3*(2), 105-111. https://rb.gy/uaqdm6

Toh, S. C., Munassar, W. A. S., & Yahaya, W. A. J. W. (2010). Redundancy effect in multimedia learning: A closer look. In C. H. Steel, M. J. Keppell, P. Gerbic & S. Housego (Eds.), *Curriculum, technology & transformation for an unknown future: Proceedings Ascilite Sydney 2010* (pp. 988-998). The University of Queensland. https://rb.gy/a7eute

United Nations International Children's Emergency Fund. (2020). *How many children and young people have internet access at home? Estimating digital connectivity during the COVID-19 pandemic*. https://rb.gy/i3b20z

Van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *SAGE Open*, *10*(1), 1-14. https://doi.org/10.1177/2158244019900176

Van Merrienboer, J. J. G., & Sweller, J. (2005). Cognitive load theory and complex learning: Recent developments and future directions. *Educational Psychology Review*, *17*, 147-177. https://doi.org/10.1007/s10648-005-3951-0

Vinayak, J., Cockerill, M. E., Comeau, T. C., & Lee, T. H. (2009). *Utilizing video multimedia tools in biology labs* (Project EL08). https://rb.gy/s9cnep

World Bank. (2010). *The education system in Malawi* (World Bank working paper no. 182). http://hdl.handle.net/10986/5937

Yusuf, M. O., & Afolabi, A. O. (2010). Effects of computer assisted instruction (CAI) on secondary school students' performance in biology. *The Turkish Online Journal of Educational Technology*, *9*(1), 62-69. http://www.tojet.net/articles/v9i1/918.pdf

Zeitlyn, B., Lewin, K. M., Chimombo, J., & Meke, E. (2015). Inside private secondary schools in Malawi: Access or exclusion? *International Journal of Educational Development*, *43*, 109-117. https://doi.org/10.1016/j.ijedudev.2015.05.008