Comparing YouTube Videos and the Lecture Method in Teaching Kinematics in Tanzania's Teachers' Training Colleges

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Abstract
Understanding kinematics is crucial in physics, yet many students struggle to interpret these concepts. This study aimed to improve students' performance in kinematics through YouTube videos in Tanzanian teachers' training colleges. It employed a quasi-experimental design with control and experimental groups, comprising 103 pre-service physics teachers from two diploma teachers' training colleges in the Iringa and Mbeya regions. Participants in the control group learned kinematics concepts using the lecture method, while those in the experimental group learned through YouTube videos. Data were collected by administering tests before and after classroom interventions and were analysed using both independent- and paired-sample t-tests. The independent t-test showed that the YouTube video class improved significantly, with a pre-test effect size of 0.04 ($p > 0.05$) increasing to a post-test effect size of 0.83 ($p < 0.001$). The paired t-test also indicated a strong post-test gain in the YouTube video class (effect size = 1.33, $p < 0.001$), while the lecture class showed minimal improvement (effect size = 0.26, $p > 0.05$). The study recommends engaging students in learning through YouTube videos because they are visually appealing and often incorporate real-world examples, which enhance students' understanding and retention of complex physics concepts.

Keywords: Kinematics concepts, lecture method, physics, teachers' colleges, YouTube videos

Introduction

Learning physics is important for all students because it helps develop new technological skills that benefit mankind (Ellermeijer & Tran, 2019). Many modern breakthroughs demonstrate how physics helps improve the world. For instance, these include nuclear energy Kristensen (2016), the invention of computers (Wolf, 2016), and electricity (Pandey, 2020). Physics has contributed to the world, but in many developing countries, students' performance in physics has been poor over the years. For example, in Tanzania, despite the lowest enrollment in physics for the Certificate of Secondary Education Examination (CSEE) compared to other science disciplines like chemistry and biology, students' performance in physics has remained below 50% and has been the lowest among other science subjects (President's Office - Regional Administration and Local Government [PO-RALG], 2019, 2020). Table 1 shows students' performance and enrollment in physics, chemistry, and biology in the CSEE from 2017 to 2019.

Table 1
Performance and Enrolment of Science Students in CSEE

Years	**Science subjects**					
	Physics		**Chemistry**		**Biology**	
	Enrolled	**Passed**	**Enrolled**	**Passed**	**Enrolled**	**Passed**
2017	131,243	42%	160,126	53%	322,184	61%
2018	133,616	46%	165,776	62%	359,302	61%
2019	128,444	48%	162,777	77%	421,562	55%

Source: PO-RALG (2019, 2020)

In Table 1, students' performance in chemistry and biology exceeded 50% for the past three years, whereas students' performance in physics was below 50% in all years, despite the lowest number of enrolled learners each year taking the CSEE. This indicates that students face greater challenges in understanding physics concepts than in other science subjects.

Students have consistently performed poorly on certain topics in physics examinations over the years. One of these topics is motion in a straight line. It is a core topic in physics that students are required to study in many countries (Ole & Gallos, 2023). Concepts in this topic include position, displacement, speed, velocity, and acceleration, among others. These concepts can be represented as kinematics graphs and expressed as kinematics formulas (Amin et al., 2020). Scholars have acknowledged the significance of this topic as the foundation for other ideas (Beichner, 1994; Laverty, 2013; Planinic et al., 2013). Inadequate understanding of kinematic concepts may lead to poor understanding of related concepts in other topics (Manurung et al., 2018). For example, knowledge of kinematics is essential for enhancing students' understanding of Newton's laws of motion and for developing graphing skills during experiments in other physics topics and other subjects. According to Susac et al. (2018), researchers in mathematics, science, and educational psychology use kinematics graphs to explore learners' graphing abilities. Graphs are essential in physics because most experiments involve plotting them to interpret data more easily. A graph is the most effective statistical tool for helping researchers identify patterns in complex data (Beichner, 1994; Laverty, 2013). Thus, through graphs, it is possible to minimize the use of complicated formulas.

In Tanzania, the topic of motion in a straight line is taught to Form Two students, typically ages 14 to 15. Students' performance on this topic in the Form Two and Form Four national examinations has been poor for several years. For example, in 2019, Form Four candidates were required to calculate the time taken for an object to travel upward to a height of 20 meters (National Examination Council of Tanzania [NECTA], 2019b). The majority could not respond correctly because they lacked a solid understanding of kinematic concepts related to motion under gravity. Likewise, many Form Four students could not determine the velocity of a stone dropped from the top of a building that hit the ground 4 seconds later, due to insufficient knowledge of motion under gravity (NECTA, 2020b). Moreover, for the past five years, from 2017 to 2021, Form II students' average performance on the topic of motion in a straight line did not exceed 21% (NECTA, 2017, 2018, 2019a, 2020a, 2021).

Students' weak performance on the topic is attributed to both students' and teachers' low conceptual understanding of kinematics, including inadequate knowledge of how to interpret graphs and an inability to solve problems presented in graphical form (Amin et al., 2020). Pre-service teachers in colleges and universities can face similar challenges. For example, the study by Mbwile and Ntivuguruzwa (2023a) revealed six challenges facing Tanzanian pre-service physics teachers when working with kinematics graphs, including difficulties in interpreting the slope of a line graph that does not start from the origin, neglecting the time an object spends at rest when plotting graphs, and difficulties in calculating total distance when forward and backward directions are involved, among others. Pre-service teachers' understanding of these concepts is critical because if these weaknesses remain unaddressed, they will be passed on to their future students.

In this regard, efforts are needed to improve students' and teachers' conceptual understanding of the topic. A key step is to move away from traditional teaching methods, such as lectures, which often limit students' understanding of kinematics. Many educators agree that traditional lectures are less effective than active learning methods, such as discussions, hands-on tasks, problem-based learning, and role-play (Kay et al., 2019; Revell & Wainwright, 2009). A limitation of the lecture method is that it positions students as passive recipients of information processed by the teacher (Marmah, 2014). Thus, students' dependence on the instructor reduces their responsibility for self-directed learning and subjects them to rote learning.

In an era of increasingly active learning and a focus on more student-centered approaches, YouTube videos have become a technological tool that helps students better understand and retain difficult physics concepts (Mbwile & Ntivuguruzwa, 2023b). Difficult topics can be made understandable through YouTube videos, which can include animations, demonstrations, and real-life applications, engaging learners through both visual and auditory means (Mjenda et al., 2023; Ndihokubwayo et al., 2020; Njiku et al., 2022). This multisensory format makes complex concepts easier to understand and increases students' engagement and motivation during the lesson. Learning through YouTube videos aligns with the Tanzanian government's initiatives to modernize education and integrate technology into the curriculum (Tanzania Institute of Education [TIE], 2007).

Since its founding in February 2005, YouTube has enabled users to upload content ranging from short to long videos (Gustafsson, 2013). Teachers sometimes struggle with a lack of teaching resources, even though hundreds of helpful videos are uploaded to YouTube every day (Jones & Cuthrell, 2011; Mbwile & Ntivuguruzwa, 2023b). Most of these videos are free to view; all that is needed is an internet connection. YouTube videos serve as both a teacher resource (teachers access instructional materials) and an instructional tool (students view relevant YouTube videos) (Gustafsson, 2013). In Tanzania, where access to educational resources can be limited, YouTube offers an accessible and affordable alternative. This accessibility can help bridge the gap in educational resources by enabling students to engage with YouTube materials.

The global lockdown caused by the COVID-19 outbreak compelled many educational institutions to adopt platforms like YouTube to deliver online instruction (Ahmed et al., 2022; Mbwile & Ntivuguruzwa, 2023b; Tendo, 2023). Although online instruction existed before the pandemic, it garnered significant attention during the COVID-19 pandemic (Hassan et al., 2020; Nan & Yong, 2022). Using YouTube videos to teach complex physics concepts related to kinematics can significantly improve students' performance. Students' consistently weak performance on kinematics concepts, along with the lack of research in the Tanzanian context on the use of YouTube videos for learning kinematics, motivated the study to compare the effectiveness of lectures and YouTube videos in teaching kinematics concepts.

Statement of Research Problem

Students' performance on the topic of motion in a straight line in the Form Two and Form Four national examinations is very low. For example, in 2019 and 2020, students' mean performance in FTNA was 11.7% and 12.5%, respectively (NECTA, 2019a, 2020a). According to NECTA (2018), this is considered poor performance because it falls below the minimum required average of 29%. Students' weak performance in this topic is attributed to low conceptual understanding among both students and teachers, stemming from the dominance of traditional teaching methods, particularly in physics classrooms. In this regard, efforts to use active learning methods to teach kinematics concepts are required. YouTube video-based instruction, which often includes animations, demonstrations, and real-life applications, can make difficult topics easier to grasp (Mbwile & Ntivuguruzwa, 2023b; Mjenda et al., 2023; Njiku et al., 2022). Very little is known with certainty about the effectiveness of YouTube videos in teaching and learning kinematics concepts in Tanzania. Thus, researchers were motivated to compare the effectiveness of YouTube video-based instruction with the lecture method in teaching kinematics concepts.

Research Objective

To assess the effectiveness of the lecture method and YouTube videos in teaching kinematics concepts

Research Hypothesis

The study was guided by the following null hypotheses:

1. There is no statistically significant difference in performance between students who were taught kinematics concepts using the lecture method and YouTube video classes.
2. There is no statistically significant difference in performance between pre- and post-tests on kinematics concepts in the lecture method and in YouTube video classes.

Literature Review

Using YouTube Videos in Teaching

Integrating YouTube videos into classroom instruction can help mitigate some of the issues students face when learning complex topics, such as failed experiments and health and safety hazards associated with hands-on activities (Berk, 2009). Videos can be used to demonstrate concepts for both kinaesthetic and auditory learners. Hence, empirical studies on the use of YouTube videos in teaching have been conducted globally, across Africa, and in Tanzania.

Studies Conducted Globally

The reviewed studies show that YouTube is a valuable resource for instructional planning worldwide. YouTube supports teacher preparation, enriches instruction, and enhances students' understanding across various settings. In the United States, Jones and Cuthrell (2011) found that using YouTube has helped teachers plan classroom instruction more effectively, thereby improving student performance. These findings indicate that YouTube video-based instruction can support teachers' preparation and students' comprehension of the subject matter, improving students' learning outcomes.

In the same vein, Gustafsson (2013) studied how physics is presented in physics-related videos on the platform YouTube in Sweden. The results highlighted a range of practices for using YouTube in science and physics teaching, such as recording lectures, featuring students' work, and providing classroom resources. The results demonstrate the potential of YouTube as a teaching tool, using lecture recordings, student-made videos, and carefully selected science resources to augment learning, increase conceptual understanding, and boost engagement in the physics and science classroom. Similarly, Wong (2020) examined the effectiveness of video clips for learning science in Malaysia. The results revealed that students considered watching videos to be highly useful for understanding the subject matter. This suggests that visual content enhances understanding, clarifies complex concepts, and motivates and engages learners. In summary, the results indicate that YouTube-based instruction can enhance students' learning.

Studies Conducted in Africa

In Africa, students who learn through YouTube videos have a 65.9% comprehension rate, are more engaged, and achieve better academic outcomes than students who learn through traditional lecture methods, who have a 51.7% comprehension rate and are less engaged. For example, in Lesotho, Bohloko et al. (2019) assessed the effectiveness of using YouTube videos to teach chemistry. The study found that participants who watched the YouTube videos (experimental group) performed significantly better than the control group (lecture method). The experimental groups' superior performance compared with traditional lectures suggests that using videos increases students' understanding, engagement, and academic achievement.

Chtouki et al. (2012) conducted a study on the effect of using YouTube videos on students' learning in Morocco. The results of this study show that students have a much deeper understanding of information presented in videos with visual explanations of complex concepts. The findings suggest that when students can see an explanation, they understand complex subjects more easily, and that the use of multimedia learning resources could increase students' achievement. In addition, Ndihokubwayo et al. (2020) conducted research in Rwanda on the effectiveness of PhET simulations and YouTube videos in enhancing optics learning in secondary schools. The post-test results found that students who were taught using the PhET simulation and YouTube video outperformed those who were taught using the traditional teaching method. This indicates that PhET simulations and YouTube videos are more effective at strengthening students' understanding than traditional teaching methods. Globally, as seen in African studies, the use of YouTube videos and other multimedia tools has consistently been shown to improve both students' comprehension and achievement, and is clearly superior to traditional lecture-based approaches to teaching students, making it much more effective at simplifying complex concepts and improving learning outcomes.

Studies Conducted in Tanzania

Although YouTube technology is not widely used in many educational institutions in Tanzania, its use in teaching and learning is slowly growing, providing opportunities to enhance student engagement, make complex concepts easier to grasp, and improve academic performance. For instance, Mtega et al. (2013) studied the possibilities of Web 2.0 technologies in the teaching of higher learning institutions. The outcomes showed that there was little use of Web 2.0 programs like YouTube, Google Drive, and blogs for learning, but not for other uses. This reveals the difference between the use of Web 2.0 tools in higher education and their pedagogical uses.

Additionally, Mjenda et al. (2023) conducted a study on computer-aided instructional techniques to enhance students' 3D geometry spatial visualisation skills. Results from the exam revealed that, in the treatment group, students performed better than in the control group with respect to spatial visualisation skills. This is because using computer-aided instructional techniques enhances students' spatial visualisation skills, as reflected in the treatment group's higher achievement in 3D geometry concepts compared with the control group. Furthermore, Mbwile and Ntivuguruzwa's (2023b) study indicated that, as a result of the post-test, students who studied kinematics graphs using YouTube performed better than those who studied using lectures. The suggestion is that learners exposed to video lessons experience multisensory engagement, in contrast to those taught through conventional lectures. From this literature, therefore, little information was found on a direct comparison of the effectiveness of YouTube videos and traditional lectures for learning kinematics concepts in Tanzania, indicating a gap that warrants investigation.

Theoretical Framework of the Study

The theoretical foundations of this study were based on constructivist learning theory and Mayer's theory of multimedia learning. Constructivists focus on what learners must do to create knowledge themselves, namely through experience and interaction. The theory is grounded in the foundational research of Lev Vygotsky, Jean Piaget, John Dewey, and Jerome Bruner (Ertmer & Newby, 1993). In the constructivist approach to teaching, learning experiences involve reflection on individual ideas, dialogue, and meaningful tasks in relation to the surroundings (TIE, 2007). Knowledge is considered to be constructed based on the learner's prior experience(s), and teaching is now an active process, rather than a passive one, as the teacher is seen to be a guide, facilitator, and motivator of learning (Adams, 2006; Baviskar et al., 2009).

YouTube video-based teaching and learning followed a constructivist approach, Emphasising active, interactive learning. The physics tutor who participated in the YouTube video class (experimental group) served as a facilitator, motivator, and guide for the learning process. The tutor also provided learning environments that bridged students' existing knowledge with new experiences. Video sessions were complemented by classroom discussions and question-and-answer sessions to ensure the effective use of constructivist learning theory. Videos were paused at times to facilitate clarification, reflection, and discussion for deeper understanding. The other group, the control group, received little support for the use of constructivist learning theory because it was taught traditionally, as in a lecture.

Additionally, Mayer's multimedia learning theory, employed in this study, suggests that the best way for people to learn is through the combination of visual and auditory channels. Dual-channel processing claims that learners' cognitive load can be reduced by distributing information across these pathways, enabling them to create strong mental models (Mayer, 2009). During the learning process, YouTube videos enabled multisensory engagement, particularly through visual and auditory channels. When learning abstract concepts such as kinematic graphs, spoken explanations paired with visual representations help students connect words describing motion to the graphical features, enhancing understanding and recall.

Research Methodology

Using a quantitative research approach, this study collected data primarily to compare the effectiveness of lecture and YouTube video interventions in a two-group quasi-experimental design. Miller et al. (2020) and Maciejewski (2020) have noted that the quasi-experimental design is commonly used to assess the effect of an intervention on two intact groups. The two groups in this design will be an experimental group, which will be exposed to an intervention using YouTube videos, and a control group, which will be exposed to an intervention using a traditional lecture-based method. Within both groups, pre- and post-tests were administered before and after the classroom interventions and analysed in SPSS.

Study Participants

The study included a sample of 103 pre-service physics teachers from two teachers' training colleges in the Iringa and Mbeya regions of Tanzania. In the present study, the two teachers' colleges, namely College X and College Y, served as the control and experimental groups, respectively, comprising 52 and 51 students. Using two different teachers' training colleges for the control and experimental groups helped avoid interactions between the two groups. The subjects were purposively selected because they had studied motion in a straight line in their secondary schools. In addition, they were studying physics, education, and one other science subject. Furthermore, as part of their teacher training, they taught regular-level secondary school students and participated in lessons on motion in a straight line during their teaching practice. Because of these factors, they were appropriate and pertinent subjects for the present investigation.

Ethical issues were addressed by obtaining ethical clearance and research permits from the relevant authorities. The study was conducted in compliance with Government Circular Ref. No. MPEC/R/10/1 dated July 4, 1980, and received research clearance from the Regional Administrative Secretaries (RAS) of the Iringa and Mbeya regions and the respective institutions. Participation was voluntary, and all participants provided written informed consent. Confidentiality and anonymity were maintained by using pseudonyms (College X and College Y) instead of institutional names, and all identifiable faces in photographs were blurred. Data were used solely for research purposes and were handled securely.

Data Collection Methods

Before being considered valid measures, the tools used for data collection in research must meet criteria for validity and reliability (Dikko, 2016). The 5 multiple-choice questions administered before and after the interventions were drawn from a published concept inventory for interpreting kinematics graphs in the Tanzanian context (Mbwile et al., 2023). The selected questions covered kinematic concepts, including interpreting the slope of a line graph, plotting graphs of an object at rest, calculating total distance when forward and backward directions are used, determining the area under kinematic graphs, and converting between kinematic graphs. The questions were emailed to 11 experts to obtain construct and content validation. Each question was rated on a 4-point scale ranging from not relevant to highly relevant, based on its degree of relevance. The average rating for all five questions was above the recommended 2.51. Furthermore, internal consistency was assessed using Cronbach's alpha (α), which was 0.83, indicating good reliability. Figure 1 shows an example of an item administered during the pre- and post-tests.

Figure 1

Example of an Item Administered During Pre-and Post-tests

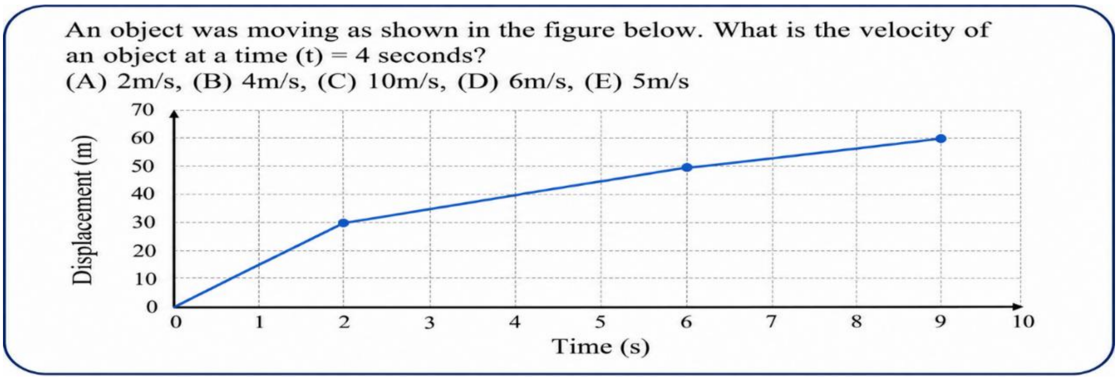

Figure 1 shows the item used to assess students' ability to interpret the slope of a line graph that does not start at the origin. The item includes the correct answer and identifies possible misconceptions that learners are likely to encounter when dealing with kinematics concepts. The correct answer, E, requires students to calculate the slope of the line graph between 2 and 6 seconds, whereas the prominent misconception, C, involves dividing the vertical coordinate by the horizontal coordinate. Thus, such a question requires a deliberate strategy for addressing learners' misconceptions.

Before data collection began, control and experimental groups were formed. College X had the control group with 52 participants, and College Y had the experimental group with 51 participants. Thereafter, a pre-test consisting of 5 multiple-choice questions on kinematics concepts was administered to all 103 pre-service physics teachers in both groups. The pre-test aimed to assess whether there was a similar level of understanding of kinematics concepts across groups. The pre-test was followed by classroom interventions using the usual lecture method in the control group and YouTube videos in the experimental group. Two physics tutors (one per group) participated in the classroom interventions, delivering lectures and YouTube videos. These tutors received special training from researchers on how to teach kinematics concepts through YouTube videos and lectures in the experimental and control groups, respectively. In addition, researchers were present throughout the entire data collection process.

During the lecture class, the physics instructor delivered lessons on kinematics using traditional teaching methods, primarily focusing on direct instruction, note-taking, and verbal explanation. Pre-service physics teachers in a YouTube videos class watched several videos from YouTube that were accessed at http://www.youtube.com/. The targeted videos covered kinematic graphs, focusing on interpreting the slope of a line graph, plotting graphs for an object at rest, calculating total distance when forward and backward directions are involved, determining the area under kinematic graphs, and converting between kinematic graphs. Keywords such as converting between kinematics graphs and velocity-time graphs were used to search for relevant videos. The videos were uploaded to YouTube by different sources, including Chhsphysics and DHart. A total of 47 audiovisual videos were obtained before researchers and physics tutors conducted an initial screening. After initial screening, 13 YouTube videos were removed, leaving 34, which were used to teach diploma college pre-service teachers.

These audiovisual videos were in English. Video lengths ranged from 5 to 15 minutes. To avoid network issues when playing YouTube videos online, all videos used to teach kinematics concepts were first downloaded from https://y2mate.com. The links for all 34 YouTube videos used during interventions were attached in a separate document. Videos were used strictly for non-commercial, educational purposes consistent with fair-use principles for classroom instruction, and creators are credited in the Acknowledgment below; researchers did not redistribute downloaded copies beyond the classroom setting. Figure 2 shows learning of kinematics concepts at College X and College Y, facilitated through lectures and YouTube videos, respectively.

Figure 2

Teaching Kinematics Concepts Using the Lecture Method and YouTube Videos

(a) Teaching Kinematics at College X through Lecture **(b) Teaching Kinematics at College Y through YouTube Videos**

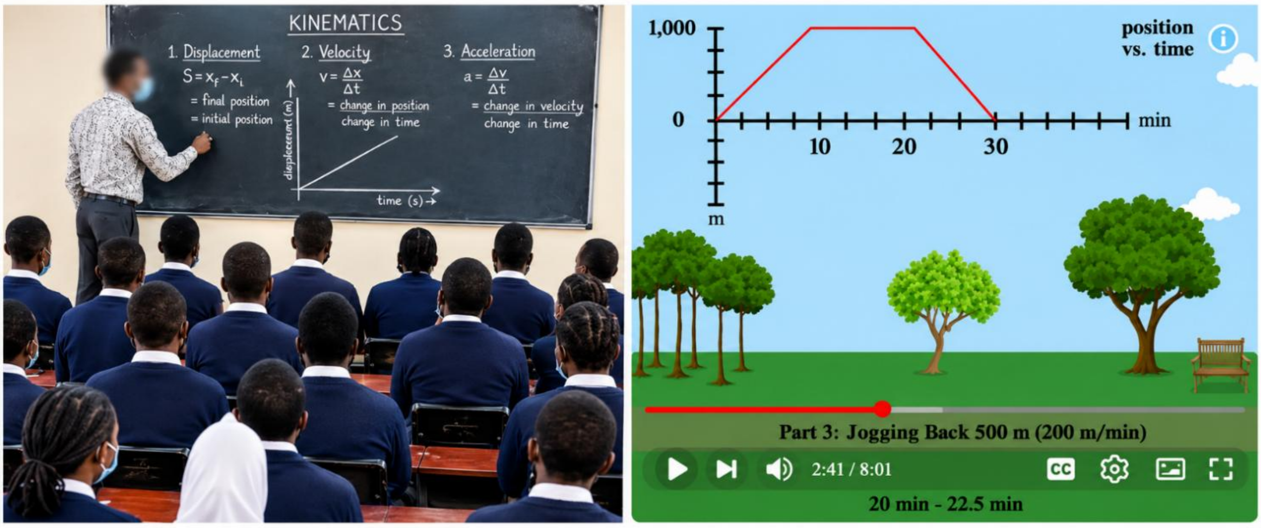

Figure 2a above shows an instance of teaching kinematics concepts through the lecture method, while Figure 2b shows students learning similar concepts by watching YouTube videos. YouTube videos were projected on the wall so that all participants could see them at the same time. Participants in the YouTube videos class watched two videos each day, for a total of four videos over two periods within the week. Participants in the YouTube videos class watched a full video, then paused for discussion and asked the physics tutor questions for further clarification before watching another video. This means the process of watching YouTube videos was facilitated by other teaching strategies, including questions and answers as well as discussions.

After classroom interventions in both the control and experimental groups, a post-test was administered to all groups. The time interval between the pre- and post-test was 9 weeks. The purpose of the post-test was to determine the effectiveness of classroom interventions in learning kinematics concepts in the two groups. In addition, comparisons were to be made between groups as well as within groups for pre- and post-test results.

Data Analysis Procedures

Descriptive and inferential statistics from pre-and post-pilots and from pre-and post-tests were analysed by using SPSS version 25. SPSS was used to compute descriptive statistics such as mean, standard deviation, and frequency of scoring correct and incorrect answers. Also, it was used to compute Inferential statistics (i.e., independent-sample t-test, paired-sample t-test, and Cohen's D effect size).

Results and Discussions

The current section examines and evaluates the study's principal findings. The section expands on the results by thoughtfully discussing them in relation to the literature on the use of YouTube videos in teaching kinematics concepts. The research was inspired by constructivist learning theory and Mayer's multimedia learning theory. Findings were generated by administering 5 multiple-choice questions on kinematics concepts before and after classroom interventions to pre-service physics teachers in both the control and experimental groups. A pre-test with 5 questions was administered to both groups to assess whether there was a similar level of understanding of kinematics concepts across groups. The frequency of correct and incorrect answers revealed that pre-service teachers in both the control and experimental groups performed poorly on the pre-test. After classroom interventions, a post-test was administered to both groups to assess their effectiveness. The purpose was to determine whether the treatments had improved participants' conceptual understanding of kinematics concepts. The frequency of correct answers indicated that participants in the experimental group performed better than those in the control group on the post-test. The frequency of correct and incorrect answers for both pre- and post-tests is shown in Table 2.

Table 2

Learners' Frequency of Correct and Incorrect Answers During Pre-and Post-test

Qn No	Pre-test				Post-test			
	Control (N=52)		Experimental (N=51)		Control (N=48)		Experimental (N=49)	
	Frequency		Frequency		Frequency		Frequency	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
Qn 1	15	37	14	37	17	31	23	26
Qn 2	14	38	16	35	16	32	25	24
Qn 3	17	35	16	35	18	30	24	25
Qn 4	15	37	13	38	19	29	26	23
Qn 5	16	36	16	35	16	32	22	27

Table 2 indicates how pre-service teachers performed on 5 items in the test in the control and experimental groups. Each item was scored 1 = correct, 0 = incorrect. Total scores ranged from 0-5 and were converted to percentage scores. The number of students who sat for the pre-test was 52 and 51, and the post-test was 48 and 49 for the control and experimental groups, respectively. The number of participants for the post-test was lower than that of those who sat for the pre-test because some participants failed to attend the post-test due to various reasons, including health-related issues. The highest score was 17 out of 52 for question 3 in the control group, while the lowest score was 13 out of 51 for item 4 in the experimental group during pre-test. During the post-test, two questions, 2 and 4, recorded students' performance of 50% and above in the experimental group, while all questions in the control group recorded students' performance below 50%. This suggests that the YouTube-videos intervention was associated with a larger performance gain than the lecture method, although the non-randomised, two-college design means alternative explanations, including instructor and institutional differences, cannot be ruled out.

Before computing inferential statistics for the pre-test, the Shapiro-Wilk normality test was conducted, which revealed that the scores were normally distributed, thus allowing for the conduct of inferential analysis using parametric methods. Table 3 provides a summary of normality test results for pre- and post-tests in both control and experimental groups.

Table 3
Pre-and Post-Pilots Results for Shapiro-Wilk Normality Test

Groups	Test	N	Significance	Data distribution
Control	Pre-test	52	0.21	Normal
	Post-test	48	0.15	Normal
Experimental	Pre-test	51	0.35	Normal
	Post-test	49	0.07	Normal

The Shapiro-Wilk Normality Test indicates that, the significance values for pre-and post-tests presented in Table 3 are above the significance level of 0.05. It signifies that, the test scores were normally distributed. These results provided a direction in which parametric statistical analyses were performed for independent and paired sample T-tests.
The summary of learners' performance for the independent-samples t-test during pre- and post-tests, including the mean, standard deviation, t-test, degrees of freedom, and p-value (sig. 2-tailed), is presented in Table 4.

Table 4
Comparing Learners' Performance Between Groups During Pre-and Post-Tests

Test	Interventions	N	Mean	Standard Deviation	T	Df	Sig.	Effect Size
Pre-test	Lecture Method	52	29.62	16.083	0.194	101	0.847	0.04
	YouTube Videos	51	29.02	15.133				
Post-test	Lecture Method	48	35.83	16.48	-4.07	95	<0.001	0.83
	YouTube Videos	49	48.98	15.31				

Table 4 makes it evident that the pre-test p-values higher than 0.05 and the low effect size of 0.04 suggest that there was no statistically significant difference between students' performance in lecture and YouTube video classes during the pre-test. These results indicate that, before classroom interventions, participants in all groups had a comparable degree of understanding of kinematics concepts. To clear students' difficulties with interpreting kinematics concepts, classroom interventions in control and experimental groups were carried out using the lecture method and YouTube videos, respectively. Therefore, the null hypothesis, which states that there is no statistically significant difference in students' performance for lecture and YouTube video classes for pre-test results between the groups, was accepted.
Also, the p-values < 0.001 revealed during the post-test indicated substantial variation in performance between lecture and YouTube video classes. In addition, the effect size of 0.83 revealed during the post-test between the experimental groups and the control group indicates a large effect. This is because, according to Cohen (1988), the effect size is considered to be small if it is 0.2, medium if it is 0.5, and large if it is 0.8. Therefore, sufficient evidence was shown to indicate substantial variation in performance between groups during the post-test. In that regard, the null hypothesis, which states that there is no statistically significant difference in students' performance between lecture and YouTube video classes for post-test results, was rejected; instead, the alternative hypothesis, which states that there is a difference in students' performance between the groups, was accepted.

Meanwhile, a paired-sample t-test for the control (lecture) group indicates that students' performance did not differ significantly between the pre- and post-test results. Results from the experimental group (YouTube videos) revealed a statistically significant difference in test scores between the pre- and post-test. Table 5 displays the paired-sample t-test degrees of freedom (df), mean, standard deviation, t-test, and p-values for the control and experimental groups.

Table 5

Comparing Learners' Performance Within Groups for Pre-and Post-tests

Interventions	N	Test	Mean	Standard Deviation	T	Df	Sig.	Effect Size
Lecture Method	48	Pre-Test	31.25	15.39	-1.80	47	0.078	0.26
		Post-Test	35.83	16.48				
YouTube Videos	49	Pre-Test	28.57	15.28	-5.0	48	<0.001	1.33
		Post-Test	48.98	15.31				

In Table 5, only pre-service teachers who completed both pre- and post-tests were included in the paired-samples t-test. The pre- and post-test results did not differ significantly in the lecture class (p-value > 0.05 for the control group), as shown in Table 5. Similarly, the small effect size of 0.26 in the lecture indicates that the method had little effect on improving students' performance. As a result, the null hypothesis, which maintains that the pre- and post-test results are identical for the control group, was accepted.

On the other hand, p-values of < 0.001 indicate a statistically significant difference between the pre- and post-test outcomes for the YouTube video class. Likewise, the larger effect size of 1.33 demonstrates that YouTube video interventions significantly improved students' performance. In other words, students' ability to grasp kinematics concepts appears to have developed alongside participation in the YouTube video intervention, although the quasi-experimental design limits the strength of this causal inference. The use of YouTube videos enabled a multisensory approach that helps students connect what they hear with what they see—namely, how the motions relate to the graphical features, thus enhancing comprehension and retention of kinematics concepts. The results were sufficient to refute the null hypothesis, which states that there is no statistically significant difference in the test scores of the video class before and after the intervention. Therefore, the alternative hypothesis that there will be a significant difference in the performance of participants in the pre- and post-tests in this YouTube video intervention was accepted.

Engaging students with YouTube videos, complemented by discussions and question-and-answer strategies when teaching kinematics, has no doubt improved students' conceptual understanding of kinematics more than the lecture method. This is because YouTube videos, when integrated with other teaching methods, tend to be more engaging than traditional lectures. Many educational videos are visually appealing and incorporate real-world examples, which help capture and sustain students' attention more effectively. Unlike traditional classroom settings with fixed pacing, YouTube videos allow students to pause, rewind, or rewatch content as needed. This flexibility is useful when the concept to be learned is complex, such as understanding the slope or area under a kinematics graph, and students might need more time to master it. Learners at different paces can review the content at their own pace, reducing the risk of falling behind or feeling rushed. Thus, when YouTube videos are properly used to teach students, they reflect the characteristics of constructivist learning theory.

The use of YouTubeeoidos technology in learning kinematics concepts aligns with Beichner (1996) and Ploetzner et al. (2009), who asserted that using technology such as videos, multimedia, modeling software, and simulations tends to improve students' comprehension of kinematics and the development of graphing abilities. Findings also align with Thornton and Sokoloff (1990), who used Microcomputer-Based Laboratory (MBL) technology in the 1990s and found that technology offers students graphing abilities by enabling the identification of moving objects on the screen. Furthermore, integrating technology such as YouTube videos into teaching parallels Svec (1999), who used MBL and found that the method was favorable because it allowed students to watch the motion event while also visualizing it graphically, which is thought to be useful for making connections between abstract concepts and practical experiences. Furthermore, teaching through YouTube videos aligns with Antwi (2015), Antwi et al. (2018), and Snir et al. (1993), who contended that learning physics in schools, particularly kinematics, has been successful when technology such as computer simulations, MBL, and modeling tools was integrated into the teaching and learning process. Moreover, findings align with Mbwile and Ntivuguruzwa (2023b), who contended that, during the post-test, students who learned kinematics graphs through YouTube videos outperformed those who learned through lectures.

Similarly, teaching through YouTube videos to improve students' performance aligns with Ljubojevic et al. (2014), who reported that including videos in lecture classes improved student performance compared with lectures alone. Likewise, findings align with De la Flor López et al. (2016), who reported that YouTube videos outperformed lectures as the most effective instructional medium for raising student performance. Furthermore, Geri (2012) found that, after watching videos, 94% of students had better comprehension of the material. Moreover, Hsin and Cigas (2013) showed that many students passed the course after videos were added to physics instruction. However, if videos are not carefully selected when providing instruction to students via YouTube, they can confuse students rather than help them understand the subject matter.

However, implementing YouTube in physics education at Tanzania's Teachers' Colleges has posed several challenges. Difficulties in accessing the internet, weak technological infrastructure, and a lack of teacher training in using video resources can impede the effective use of these resources (Mbwile & Ntivuguruzwa, 2023b). Furthermore, not every YouTube video is educational; educators need to critically assess a video's credibility and accuracy before using it in their classes (Ndihokubwayo et al., 2020).

Study Limitations

The process of data collection and analysis faced several challenges. First, the laboratory computers at the targeted teacher-training colleges for the YouTube video intervention were not functioning. This forced the researcher to conduct the YouTube video interventions on the researcher's laptop rather than on college laboratory computers. Although the class for the YouTube video intervention was large due to the shortage of laptops and projectors, participants provided useful information on learning kinematics graphs through YouTube videos. In addition, classroom interventions and the second round of data collection were interrupted by the exercise of the census, which was conducted nationwide (Tanzania National Bureau of Statistics, 2022). Schools and colleges were forced to close to allow the exercise of the census 2022 to take place. After schools and colleges were reopened, researchers resumed the process of classroom interventions and the second round of data collection.

Moreover, two tutors could have influenced the results, even though they were trained to use YouTube video-based instruction and the lecture method. This is a substantive limitation, as the observed difference between groups cannot be attributed to the teaching medium alone, since each teaching condition was delivered by a different tutor at a different college. On the other hand, with no random allocation of participants to groups and participants drawn from two intact colleges, there may be selection bias that could account for the difference between groups, even given the similar pre-test scores. These threats to internal validity are inherent to non-randomized, two-group quasi-experimental designs of this type (Maciejewski, 2020) and should be considered when interpreting the results of this study; a replication with two groups (randomized multi-tutor, multi-college) would be required to isolate the effect of the instructional medium more precisely. Moreover, the sample size decreased for both the control and experimental groups from pre-test to post-test, from 52 to 48 and from 51 to 49, respectively. Additionally, t-tests are not the appropriate test to fully represent the interaction between groups and/or pre-test scores of completers and non-completers for evidence of differential attrition. Thus, despite logistical difficulties, the influence of tutors, and methodological constraints, the study was able to obtain meaningful information about the knowledge of kinematics graphs acquired through lecture instruction and YouTube videos.

Conclusion and Recommendations

Learning through YouTube videos was associated with improved students' ability to interpret kinematics graphs, specifically to interpret the slope of a line that does not start from the origin, convert between kinematics graphs, draw a graph with the object at rest, interpret the area under kinematics graphs, and calculate the total distance covered in positive and negative directions. This was possible because interactive learning, such as observation, discussion, data collection, chart marking, and drawing inferences, was incorporated into the study of kinematics through YouTube videos during classroom interventions. Conversely, when kinematics concepts were taught using the lecture technique, students were only recipients of knowledge communicated by teachers; as a result, the lecture group showed little grasp of the concepts.

Based on the results, physics teachers are advised to use YouTube-based instruction to teach kinematics, as it has been shown to improve students' performance. In addition, educators need training to integrate video with active strategies such as question-and-answer sessions and discussions. There is also a need for infrastructure that supports offline access to avoid network challenges. Moreover, future research could explore using YouTube videos to teach other challenging physics topics where students have historically struggled. Topics such as moment of force, waves, electromagnetism, and Newton's laws of motion have often shown low performance levels among students over the years. Teaching these topics through YouTube videos can boost students' academic performance and interest in physics.

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