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Effect of the Use of Videos vs. Images in Instruction on the Achievement in Science of Grade 9 Students

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Abstract

Multimedia contributes to a well-equipped, interactive, and student-centered learning environment. Integration of multimedia into science education can enhance students' achievement and motivation to learn. This study attempts to find out which multimedia tools are more effective for students, to investigate the challenges and barriers teachers face in integrating multimedia into science classrooms, and to examine the motivation and attitudes of students. A one-group quasi-experimental design was used. The same group of students were taught using images in control condition and later with both images and videos during experimental conditions. Data was collected through both quantitative and qualitative methods using unit tests, observations, and questionnaires. Participants included four science teachers and five students from a private school in the Kaduwela educational zone, selected through convenience sampling. Data were analyzed using statistical test like the Mann-Whitney U test and descriptive statistics like the mean, while qualitative data underwent thematic analysis. The study was guided by Keller's ARCS model of motivation and by Mayer's Cognitive Theory of Multimedia Learning. Qualitative findings indicated that videos had a positive impact on students' achievement, motivation, and attitudes. However, the study also identified challenges and barriers faced by teachers when using multimedia in classrooms. Post test results indicated no statistically significant difference between the control and experimental groups at a 0.05 level. This study is significant for helping educators understand how multimedia meets students' needs in science education. The findings will also contribute to academic literature and practical applications in the field of educational technology.

Keywords: Mayer's Cognitive Theory of Multimedia Learning; Keller's ARCS model; Mann-Whitney test; Images; Videos

Introduction

Multimedia combines diverse forms of elements such as audio, text, graphics, animation, and video to present information. Multimedia offers a variety of powerful tools that can help transform the traditional classroom into an interactive and vibrant learning environment (Mahajan, 2012). Videos can illustrate complex concepts more simply, which is often more beneficial than spoken explanations alone (Liu, Peng, Kang, Iliyasu, Niyato, & Abd El-Latif, 2020). Multimedia facilitates the development of fundamental skills, enhances conceptual understanding, fosters collaborative learning, and assists teachers in effective classroom management. Multimedia technology is adopted and experimented with different academic organizations worldwide through their designed methods (Kumar & Agarwal, 2016).

The use of multimedia instruction has proven to be highly effective, significantly arousing learners' motivation to learn. It provides distinct and valid information, impacts positively on the attitudes of students and promotes

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independent learning (Sun, Fu, Zang, & Chen, 2022). A significant relationship was found between the abundance of technological practices in teaching and students' attitudes towards science. The study showed the importance of incorporating interactive technological practices that address different learning styles of students (Yildirim & Kansiz, 2017, as cited in Yildirim & Sensoy, 2018). The emotional design in the multimedia learning process focuses on enhancing motivation and emotion through visual elements such as colors, shapes, and cartoon-like figures (Estrella & Mayer, 2014). It has been found that the integration of multimedia has a positive effect on students' science achievement in the Sri Lankan school system (Perera, 2011). The ARCS model (Attention, Relevance, Confidence, and Satisfaction) was developed to understand the main effects of motivation on learning. (Keller, 2010).

The use of multimedia cannot replace hands-on learning, but it can significantly enhance and reinforce activities within the science classroom. Utilizing modern information tools such as streaming video and audio allows educators to effectively demonstrate scientific concepts. Some schools have adopted strategies that use the internet and digital media to enhance traditional education. However, multimedia use also comes with certain barriers in education. These barriers include a lack of proper knowledge and skills, time constraints, limited resources, high maintenance costs, and an unfriendly user interface (Butler & Sellbom, 2002). This study is based on Mayer's Cognitive Theory of Multimedia Learning, which emphasizes that students learn better through combined verbal and visual inputs (Mayer, 2002).

This research also aims to find out which technological tools are most effective in enhancing students' learning in science education as well as which technological tool/tools are most preferred by students. Moreover, this study will help to understand how technology can facilitate motivation in students in science education. The purpose of this research is to investigate the impact of using multimedia in science education. This paper aims to determine whether the use of videos and images when teaching science lessons can have a positive impact on students' achievement, attitudes and motivation in comparison to the use of only images when teaching science. The study shows why it is beneficial to integrate multimedia in the classroom. However, the extent to which multimedia technology can truly enrich learning experiences remains a topic of ongoing exploration and debate. Even though multimedia tools like images and videos are useful in science education, earlier studies have rarely compared the effects of using images and videos in science education. There are not many studies with the direct comparison of their effectiveness in science education. Additionally, limited research has explored the barriers and challenges faced by teachers when integrating multimedia into science education. Addressing this gap is crucial for upgrading the effectiveness of the teaching-learning process in science education within the Sri Lankan context.

Objectives of the Research

This study was guided by the following research objectives to accomplish its purpose.

1. To identify which multimedia tool(s) are most effective for students in science education

2. To investigate the challenges and barriers faced by teachers in integrating multimedia into science classrooms

3. To examine students' performance, motivation, and perceptions oof learning science through these of multimedia

Hypothesis of the Study

The following hypothesis was developed in accordance with the objectives of the study.

Grade 9 students who learn science using both video and images show higher achievement in science than those who learn science using images only.

Methodology

Research Design

A quantitative-qualitative mixed method was used in this study. As stated by Johnson and Onwuegbuzie (2004) when the research approach was mixed mode, it helps to reduce the disadvantages associated with relying on a single method. The study employed a one-group post-test quasi-experimental research design for the quantitative aspect of the study. Post-test can be used to compare the marks of students and to find the effect caused by intervention. The observation method and open-ended questionnaires were used to collect the qualitative aspect of the research. One questionnaire was used to investigate students' attitudes and motivational aspects, while the other was used to examine the challenges are.

Sample and Instruments

A convenient sampling method, a type of non-probability sampling, was chosen due to the researcher's easy access to participants. The participants were five students from Grade 9 who were studying the national curriculum in science in English medium from a private school in Jayawardhanapura Education Zone. Furthermore, four science teachers from the same school were selected to participate in a survey using an open-ended questionnaire. As mentioned earlier, the study was conducted with a single class of five students as only one Grade 9 class was available at the school. Therefore, the same group of students was used for both the control and experimental conditions. Thus, the sample included five students and four science teachers.

One main instrument used in the study was open-ended questionnaires. These questionnaires were distributed to students and teachers through an online Google Form link. The questionnaire given to students included items based on Keller's instructional material motivational survey (Keller, 2010) and was administered using a Likert scale to measure the motivational effect. The second questionnaire was given to science teachers in the school to identify challenges and barriers that arise when integrating multimedia into the teaching/earning process.

Another data collection instrument used in this study was unit tests. Each unit test paper was composed of twenty multiple-choice questions. Each question included four distractors with only one correct answer. The unit test papers were developed by the researcher based on expert opinion and aligned with the lesson objectives. They were reviewed by two experts in the school: the sectional head and the secondary school coordinator. Based on their feedback and suggestions, some questions were revised to produce a final set of 20 multiple-choice questions.

The study was conducted over a period of 10 weeks. Five lessons, namely Nature and Properties of Matter, Force, Pressure, Natural resources, Micro-organisms, were taught using images only. For each lesson, the relevant content was explained while showing the images through a multimedia projector. This continued over a period of five consecutive weeks, with one lesson taught each week. For example, in the lesson on "Nature and Properties of Matter" images were used to illustrate the arrangement of particles in solids, liquids and gases. In the lesson on "Force" images were used to explain how objects are pulled, pushed or compressed by invisible forces.

Another five lessons, namely "Human Eye & Human Ear, Human Circulatory System, Electrolysis, Lightning and Natural disasters" were taught using both images and videos. For these lessons also the relevant content was explained while showing the images and videos through a multimedia projector. For example, in the lesson on "Human Circulatory System, animated videos were used to show the flow of blood, oxygen transport within the human body, and heart pumping, while images were used to explain the parts of the blood circulatory system. In the lesson on "Electrolysis" videos demonstrated the decomposition of water into hydrogen and oxygen, while images were used to discuss the experimental setup. Each lesson was taught for one week and continued over five consecutive weeks with a duration of 40 minutes per period as part of the regular school timetable. The selected lessons had not been taught previously. Observations were taken by researchers during the lessons and recorded.

Multiple instruments were used in this study as depending on a single instrument could lead to distortions or biases in certain information (Kothari, 2004).

The Method of Data Collection and Analysis of Data

The purpose of the study was explained to the school management and permission was requested to conduct unit tests and administer questionnaires to Grade Nine students and science teachers at the school.

After completing a particular lesson, the unit test was conducted by the researcher during the regular science class period within the normal classroom schedule. Students were asked to answer the questions within 40 minutes. The highest mark a participant could score on the test was 100 points. The marks scored by participants were recorded separately. One questionnaire was given to students (participants) once the selected lessons were completed. The other questionnaire was given to teachers (participants) during the final week of the study. All the participants were asked to give their honest responses. Anonymity was ensured and participants were informed that their responses would be kept confidential. Observations were conducted daily during the lessons.

A 16-item questionnaire was administered to the students, while a separate 5-item questionnaire was given to teachers. Both questionnaires were designed using 5-point Likert scale ranging from "strongly agree" to "strongly disagree. Responses from the motivational questionnaires were analyzed based on the motivational components of the ARCS model of motivation (Keller, 2010), with items grouped to represent each element of the ARCS model.

Thematic analysis was used to examine the classroom observations The observations recorded during the lessons were transcribed and categorized according to emerging themes.

Due to the small sample size, non-parametric inferential statistics were used. The Mann-Whitney U test was conducted to determine significance differences between the experimental and control group means, with a significance level set at 0.05.

(https://www.socscistatistics.com/tests/mannwhitney/default2.aspx)

Results and Discussion

Quantitative data were analyzed using descriptive and inferential statistics and qualitative data were analyzed thematically. Descriptive statistics such as the mean were used to analyze data.

Data Analysis for Research Objective 1

Observations were taken during the control condition and experimental condition. They were categorized under four key themes namely "Student Engagement, Understanding, Critical thinking and Analysis, and Creative Responses" (Table 1).

Table 1

Categorization of Observations of Students

Theme number	Theme	Observations during Control Condition	Observations of Experimental Condition
01	Student Engagement	Students paid attention to the details in the images and compared them with the things that they learned. Students engaged in discussions with peers about the images.	Students were more attentive during the lesson. Students showed expressions of surprise, curiosity and excitement. Students appeared fully engaged during the lesson.

		They shared their thoughts with others.	They listened well and followed along the instructions. Every student appeared to be focused on the lesson.
02	Understanding	Students could describe content accurately. They recognized and recalled relevant details.	Students understood abstract concepts and complex ideas well. Students remembered a greater amount of content. Students attempted to relate the things that they saw with the real-life things.
03	Critical thinking and Analysis	Students asked questions about the images. Students related the image to prior knowledge, different concepts or personal experiences.	Students made predictions about what will happen next. Students had a desire for deeper understanding. Students offered different interpretations, considered multiple viewpoints and brought diverse perspectives.
04	Creative Responses	Students were inspired to do related drawings.	Students responded attentively to questions in less time. Students pointed out different outcomes, alternative perspectives and future scenarios. Students brought up different interpretations.

According to the observations, students were more active and engaged when using both images and videos. More observations were recorded during the experimental conditions indicating that the use of both images and videos was beneficial. During the experimental condition students showed high levels of engagement as they appeared more attentive, focused and responsive. Students demonstrated a strong understanding of abstract and complex concepts and made real-life connections. Students were able to make predictions and offer interpretations. In contrast, during the control condition students had lower engagement as they were less attentive. They showed limited understanding. Students could not make many predictions and interpretations. They also struggled to provide creative responses to the questions asked. This underscores the effectiveness of using both images and videos in learning science, as these tools touch multiple senses and improve the learning process by providing rich, dual-channel input. These findings align with Mayer's Cognitive Theory of Multimedia Learning (2002) that highlights the significance of using both auditory and visual elements to improve understanding. Table 2 illustrates the mean marks obtained on post-tests in both approaches.

Table 2

Post-test Mean Marks

Group	Post-test Mean Marks
Control	66
Experimental	80.8

The U-value was calculated using the mean values of the marks of the students in the control group and that in the experimental group. The U-value is 6. The critical value for U at $p < 0.05$ is 4. Therefore, the result is not significant at $p < 0.05$. Additionally, the z-score is -1.25336. The p-value is 0.10565. Thus, the result is not significant at $p < 0.05$.

Data Analysis for Research Objective 2

The observations taken by the researcher while conducting the lessons and the responses given by teachers in the questionnaire were considered to identify the challenges and barriers faced, from the teachers point of view. Four themes were generated: "environmental distractions, language barriers, technical issues, and teacher preparedness & workload. Table 3 presents the categorization of observations and responses of teachers for the questionnaire.

Table 3

Categorization of Observations and Responses Related to Challenges

Theme number	Theme	Observations and Responses
01	Environmental distractions	The sound was not enough, due to the noise from neighboring classrooms. Issues with arrangement of class space and school space organization
02	Language barriers	Students could not follow the accents in videos. In some videos, subtitles were not available.
03	Technical issues	Projectors, speakers, and laptops did not work as expected. Insufficient bandwidth and internet speed. Insufficient number of interactive whiteboards.
04	Teacher preparedness and workload	Additional time had to be spent selecting relevant images and videos, which increased the workload of teachers.

Through this study, it was found that several challenges and barriers occur when using multimedia in science education. These different types of issues limit the teacher in delivering lessons in an interactive and engaging manner. Furthermore, they disrupt the flow of lessons and reduce the impact of multimedia content. According to the above-mentioned observations, various challenges and barriers can interrupt the use of multimedia in science education. These challenges affect science education by limiting its potential to bring up the learning experience. These findings correspond with the earlier study of Butler and Sellbom (2002).

Data Analysis for Research Objective 3

Table 4 presents the responses of the motivational questionnaire. They were analyzed based on the elements of the ARCS model: Attention, Relevance, Confidence and Satisfaction (Keller, 2010). For each component of the ARCS model, mean values were calculated in percentages.

Table 4

Analysis of ARCS Model on Students

Element	Item	Percentage (%)	Average
Attention	Use of images and videos during the class stimulates my attention	100	100
Relevance	I can easily understand the topic with the integration of image and videos technology	100	100
	Use of images and videos awakens my interest in the class	100	
	Through the images and video, it is easy for me to remember the details.	100	
	I don't feel sleepy when images and videos are used in the lesson.	100	
Confidence	I can compare and contrast things easily when images and videos are used.	100	100
	I acquire broader knowledge about the lesson when images and videos are used.	100	
Satisfaction	Use of images and videos awakens my interest in the class	100	100
	Use of images and videos inspires me to learn.	100	

The overall motivational effect in the ARCS model (the overall effect of Attention, Relevance, Confidence, and Satisfaction) was calculated by considering the responses provided by students in the questionnaire. The average value was found to be 100% (Keller, 2010).

Table 5 shows some of the responses given by students during the lessons conducted by the researcher under both control and experimental conditions.

Table 5

Responses of Students

	Responses of Students
Control Group	"Sometimes I don't get it from the text, but when I see the image, I can understand well"

	"I can focus more when there is an image" "Sometimes I get confused with the content, but when I see it, I get it"
Experimental Group	"It's a nice video" "Can you play the video again" "Yesterday teacher showed some nice videos, you missed them"
	"I like it when the teacher shows some videos and then explains it with images."
	"It feels more interesting, and I don't t get bored".
	"I can understand everything clearly"
	"I can remember things better when I see both images and videos"
	"Sometimes I watch the videos shown by the teacher again at home, it helps me to learn science well"

According to Table 5, there were more responses from students in the experimental group. This highlights that the use of both images and videos helps in motivating students to learn science. The responses of students showed that they had a positive attitude towards the use of multimedia in science lessons. This shows that when teaching is enriched with multimedia, it can notably improve students' attitudes towards learning science. According to their responses, multimedia was highly engaging and effective for helping students understand scientific concepts. This was clearly reflected in the observations as well. The researcher observed that during the experimental conditions, students were more engaged and explored a broader scope of learning. This finding aligns with the earlier studies of Sun, Fu, Zang, and Chen (2022) and Estrella and Mayer (2014).

Limitations and Suggestions for Future Research

There were several limitations of this study. The duration of students' engagement in both learning modes did not last long enough to have a significant impact. Additionally, the impact of the two distinct approaches on information retention could be examined if the tests were conducted after a longer period. The small sample size may have influenced the results. It would be preferable to conduct the study with a larger sample size, over an extended period. It was difficult to find videos that were both educationally sound and aligned with curriculum standards. Another limitation was the lack of geographical diversity in the sample, as it was confined to the Kaduwela educational zone and drawn from a single school. These constraints may have impacted on the reliability and validity of the current study's findings. Since the sample size is quite small, the results may not be suitable for a generalization. Therefore, this study can be considered a pre-pilot study.

Future studies could explore the long-term effects of using multimedia in science education. Furthermore, future researchers could investigate the most effective multimedia tools for different scientific topics and age groups. It appears necessary to conduct further research with a larger sample size to determine which multimedia tools best support students' achievement, motivation, and preferences in learning science.

Conclusion

According to the qualitative data, it can be concluded that students strongly preferred using both images and videos during science lessons.

Another conclusion from this research concerned different challenges and barriers. These distractions emphasize how crucial it is to provide a suitable classroom environment for using multimedia in the teaching-learning process. This study highlights the necessity of having well-chosen instructional resources. The workload of teachers can be alleviated with institutional support. Other significant practical challenges, such as lack of adequate digital content and teaching materials, reduced time for discussion of subject matter when showing images and videos during

limited class periods, limited access to up-to-date, scientifically accurate visual resources, and sometimes the requirement of subscriptions or purchase for high-quality videos, need to be addressed. At least some of the selected lessons should include videos and images.

With the results of the ARCS model, it can also be concluded that students were more motivated when images and videos were used in science lessons. The interest, motivation and engagement of students in learning science increased. Multimedia captured students' attention and fostered greater curiosity and interest in learning science.

According to the inferential statistics, the results are not significant. Under quantitative approach, it can be stated that including videos in lessons did not significantly improve the effectiveness of learning science in terms of achievement compared to the use of images alone. Therefore, the hypothesis of the study: "Grade 9 students who learn science using video and images show higher achievement in science than those who learn science using images only" was not supported.

This study offers valuable insights by advancing inclusive and effective science education through multimedia tools. By demonstrating how multimedia can enhance learning science, particularly for students with diverse learning needs, the study supports more equitable access to quality education. In the long term, fostering scientific literacy among students contributes to building an informed society.

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