Teaching Effectively with Multimedia and Its Impact on Students' Academic Performance in Chemistry: A Case Study

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Abstract

This study investigated the impact of integrating multimedia into chemistry education in Bhutanese higher secondary schools and its influence on students' academic performance. The research focused on assessing students' academic performance through test scores and semi-structured interviews. A sample of 62 eleventh-grade students participated in the experimental research, which aimed to explore how multimedia applications affect the content, quality, and retention of students' knowledge in chemistry. Data were collected by using a self-administered questionnaire and achievement test. Descriptive statistics and independent samples t-tests were used to analyze the data. A paired samples t-test was used to analyze the data.

The analysis result of the pre-test showed no statistically significant differences, which in turn proves the equivalence of the two groups. The t-test result showed a significant difference between the achievements of the two groups at a significant t-value of 0.05 in the post-test. The experimental group gained higher mean scores than the control group. From the self-administered questionnaire, results showed that when multimedia was integrated into teaching chemistry, students displayed a high level of learning satisfaction.

The findings revealed that the integration of multimedia increased the academic performance and learning satisfaction of students in chemistry lessons compared to the traditional methods of teaching.

Keywords: *Teaching effectively, Multimedia, Academic performance, Learning Satisfaction, Case study*

Background

"Education is what survives when what has been learned has been forgotten"

– B.F. Skinner

In the traditional education setting, the teacher assumed the role of the sender or source, delivering educational materials as information or messages, while the students acted as receivers of this information. The predominant method of delivering the message has been the "chalk-and-talk" approach, where the teacher imparted knowledge through direct instruction. This instructional model is rooted in the behavioural learning perspective, as established by Skinner (1938), and has been widely employed in educational institutions for many years. Essentially, the teacher delivered lectures while the students passively listened, resulting in limited engagement from the learners themselves (Orlich et al., 2010). However, the traditional educational approaches have revealed a discrepancy between what is taught to students and the skills demanded by the job market (Cobo, 2013). Consequently, many institutions are transitioning towards problem-based learning as a means to foster creativity, critical thinking, and analytical skills in graduates. In this particular study different multimedia technologies like video, simulation, PowerPoint, projector, and Google Classroom were utilized to enhance the teaching methods and academic performance of students in chemistry. These multimedia tools are commonly employed by teachers in Asian countries, where notable improvements in student outcomes have been observed (Bulut, 2019).

In the current educational context, learning is approached through the application of the scientific method, which involves making empirical observations, formulating hypotheses to explain those observations, and testing those hypotheses using valid and reliable methods. Information and communication technologies have revolutionized teaching and learning in the classroom, offering alternative solutions to traditional approaches. Multimedia, as a technology-based constructivist learning environment, allows students to engage in problem-solving through self-exploration, collaboration, and active participation. Many researchers consider multimedia to be an effective educational technique because it engages multiple senses simultaneously, such as sight and hearing. It promotes peer learning, individual creativity, and innovation (Malik & Agarwal, 2012). Moreover, compared to traditional textbooks, multimedia study materials, including still and animated graphics, video, and audio presented in a structured manner, have been proven to be more effective tools for acquiring new knowledge (Abdulrahaman et al., 2020). Furthermore, the use of multimedia has demonstrated its effectiveness in supporting learning and enhancing

comprehension (Lysenko & Abrami, 2014).), aligning with the cognitive theory of multimedia learning (CTML), which emphasizes our ability to process multiple representations simultaneously (Mayer & Moreno, 2005). Additionally, simulations in learning situations enable students to explore and visualize graphical representations (Eilam & Gilbert, 2014). Learning through computer simulations is closely connected to a form of constructivist learning known as scientific discovery learning (Liu et al., 2011).

Undoubtedly, there is a growing interest in technology education, and the rapid advancements witnessed in recent years have been remarkable, primarily driven by the advantages offered by multimedia learning in the 21st-century classroom. Thus, the objective of this case study was to determine whether the incorporation of multimedia aids for learning resulted in a better understanding of the subject matter compared to traditional lecture-based classrooms.

Research Objectives

- To assess and compare the impact of integrating multimedia and lecture methods on the academic performance of the students.
- To find out any statistically significant differences between the experimental group and the control group in the pre and post-measurements of students' academic performance.
- To explore any relationship between the integration of multimedia in teaching and the impact on the academic performance of Bhutanese higher secondary schools.

Research Questions

- What are the impacts of integrating multimedia on students' academic performance in chemistry?
- Are there any statistically significant differences between the average marks of the experimental group and those of the control group in the pre and post-measurements of students' academic performance in chemistry?
- Is there any correlation between the integration of multimedia in teaching and its impacts on academic performance in chemistry?

Limitations of the study

As this case was experimental, it was limited to only grade 11 students in one

of the higher secondary schools. There is not enough literature and research done in the Bhutanese context to support a wider study. Most of the arguments were used referring to the findings of researchers of other countries. Another limitation is that the study has been conducted based on data collected at only one point in time rather than collection of data at different periods. The availability of time was another factor that limited in collection of data.

Literature Review

In a study conducted by Schenker (2007) focusing on technology use in statistics instruction, a meta-analysis using hierarchical linear modeling revealed that technology had a statistically significant mean effect size of 0.233, indicating its overall positive impact on achievement. Similarly, Stelzer et al. (2008) compared the efficacy of multimedia modules with traditional textbooks in teaching introductory physics and found that students who received multimedia modules performed significantly better in tests as compared to those who experienced text-based presentations only.

Furthermore, Wangchuk (2012) conducted a study specifically focused on the impact of multimedia technology in teaching science to visually impaired students, which demonstrated a statistically significant difference in academic achievement between the experimental and control groups, favouring the experimental group. Additionally, Powrel's (2012) research on the integration of multimedia technology in teaching English to pre-primary pupils also indicated that students exhibited greater growth when taught with multimedia technology compared to traditional methods.

Moreover, Shah and Khan (2015) investigated the effects of multimedia-aided teaching on students' academic achievements and attitudes at the elementary level, finding that multimedia technology was more effective in improving academic achievement and developing positive attitudes toward science. Besides that, in the study conducted by GebreYohannes et al. (2016) on the impact of multimedia in teaching mathematics, the findings showed that the use of multimedia significantly changed students' performance in the module on calculus and numerical methods. The lessons presented through multimedia were found to be more organized and easily understood. Multimedia proved to be an effective tool for teaching complex concepts, particularly in modules like calculus and numerical methods, which are traditionally challenging to comprehend through theoretical teaching methods. Based on these results, it can be concluded that the use of multimedia in teaching and learning processes can be more effective compared to the traditional approach.

Pacalda. (2020) conducted research on the effects of multimedia in teaching

science. This had implications for practice in secondary basic education and demonstrated statistically significant differences in post-academic achievement test scores between the control and experimental groups, favouring the experimental group. The results also showed that secondary-level science teachers generally have a positive attitude towards ICT in teaching science in the classroom.

In summary, these studies collectively highlight the potentially positive effects of multimedia technology on academic achievement and attitudes toward learning, supporting its effectiveness in enhancing educational outcomes. This case study sought to further explore the impact of integrating multimedia learning in Bhutanese classroom scenarios.

Methodology

Both pre-test and post-test were conducted with two similar groups of children in an unequal group design. For this reason, the intervention was performed with the EG (Experimental group). Achievement levels of the participants were measured before and after the intervention using a single-group interrupted time-series design, with only one group receiving the intervention. The Control group (CG) was selected based on observations over time, allowing for comparison in the interrupted time series analysis. The current study employed a mixed-method approach as the researcher aimed to draw knowledge from a pragmatic standpoint. This case study used experimental design to study the impact of an independent variable (integrating multimedia) on the dependent variable (academic performance). The variables were controlled, ensuring that both groups are comparable in terms of specialization, academic level, and both having undergone pre and post-academic achievement tests.

In order to confirm the selection of the experimental group and control group, the pre-test mean score was used to find out the learning ability before assigning as experimental and control group. This was done to establish that both the groups selected for the study were of similar academic learning ability to get a comparable result. Both groups were of the same learning ability (= 9.86, = 9.83). At the end of the study, a paired samples t-test was used to analyze data.

In line with the views of Nassaji (2015), quantitative research is well-suited for analyzing numerical data. In this study, numerical data was employed to provide evidence of the potential improvement in students' academic performance in chemistry through the use of multimedia. To investigate the disparities in academic performance between students who received instruction with multimedia and those who were taught using conventional methods, a self-administered questionnaire was used with

the experimental group only, to assess the students' learning satisfaction.

Table 1.1

Data Collection Tools

	EG	CG
Pre-test	CAT 1	CAT 1
Intervention	UoMs	LM
Post-test	CAT 2	CAT 2
	SAQ	

CAT 1: Pre-test of Concept Achievement Test; CAT 2: Post-Test of Concept Achievement Test

LM; Lecture Method; Use of Multimedia: UoM; SAQ: Self-Administered Questionnaire

For qualitative data collection, the study employed a self-administered questionnaire. This tool provided a framework for respondents to express their understanding in their own words (Borg & Edmett, 2019). This method of collecting data enabled the researcher to integrate multimedia resources with the measured academic performance of the students, in comparison to the traditional method of teaching. For sampling, the researcher used a convenient sampling method to select one of the higher secondary schools in Punakha Dzongkhag (see Table 1.2). The researcher intended to use convenient sampling because using convenient sampling is cheap, efficient, and simple to implement for the successful conduct of the study.

Table 1.2

Label

Group	Male	Female	Total
CG	15	16	31
EG	14	17	31
Total	29	23	62

The study analyzed the pre-test and post-test results using the statistical package for Social Science (SPSS) 24. Descriptive statistics and independent samples t-tests were used to analyze data.

Data Analysis

The result of the study showed that in the pre-test the calculated 2-tailed t-value was 0.932 which was higher than the significant t value 0.05 (t < 0.05). This indicates that it is not significant statistically, as the mean () difference between the experimental and control groups was 0.029. In the post-test, the calculated 2-tailed t-value was 0.00 which was lower than the significant t-value of 0.05 (t < 0.05) indicating statistical significance (= 10.57). It was apparent from the data analysis that there was an increase in the performance level of students in the experimental group by the end of the study.

Findings

Impact of Multimedia Integration on Academic Performance – Experimental Group

Table 1.3 below shows the findings of the pre and post-test results in the experimental group. The resulting data shows that in the pre-test and post-test, the calculated 2-tailed t-value is 0.00, which is lower than the significant t-value 0.05 (t < 0.05) indicating statistical significance, as the mean () difference is 10.68 (expt. pre-test = 9.86 < expt. post-test = 20.54).

From this finding, it might be confirmed that the integration of multimedia positively affects the academic performance of the students, as a statistically significant difference is observed between the pre and post-tests of the experimental group.

Table 1.3

T-test results of the experimental group.

Experimental Group	N	Mean ()	SD	t-value
Pre-test	31	9.86	1.517	0.00
Post-test	31	20.54	1.540	
Difference	-10.68	0.900		

The impact of traditional instruction on academic performance – Control group

Table 1.4 shows the results analysis of the control group in the pre-test and post-test. The resulting data shows that in the pre-test and post-test, the calculated 2-tailed t-value is 0.611, which is higher than the significant t value 0.05 (t < 0.05) indicating it is not significant statistically as the mean () difference in the pre-test and post-test is 0.143 (control pre-test = 9.83 < control post-test = 9.97).

From this finding, it could be asserted that the use of the traditional approach

does not significantly affect the academic performance of the students, as no statistically significant difference is observed between the pre and post-tests of the control group.

Table 1.4

T-test results of the control group.

Control Group	N	Mean ()	SD	t-value
Pre-test	31	9.83	1.706	0.611
Post-test	31	9.97	1.200	
Difference	-0.143	1.648		

The difference between multimedia integration and traditional instruction on academic performance

When Table 1.5 is analyzed, it can be affirmed that there is a significant difference between the reached values of the two groups, as the calculated 2-tailed t-value is 0.00 which is lower than the significant t-value 0.05 ($t < 0.05$). The mean difference of the experimental group is 10.68, while the mean difference of the control groups is 0.143.

This data supports the suggestion that the increase in student performance in the experimental group is higher than the increase in the control group. This increase in the experimental group, where multimedia resources were introduced, is statistically significantly higher than in the group where traditional instruction alone was implemented ($t = 0.00 < 0.05$).

Table 1.5

Group Comparison of Pre and Post-test

Pre and Post-test	N	Mean ()	SD	t-value
Experimental Group	31	10.68	0.900	0.00
Control Group	31	0.143	1.648	

Students learning satisfaction

When Table 1.6 is analyzed, it was found that students a displayed higher level of learning satisfaction (= 4.37) when multimedia resources were employed in the teaching and learning of chemistry. Students in the experimental group were substantially motivated, their learning interest level (= 4.38) increased, level of class

participation (= 4.40) and learning satisfaction (= 4.33) increased.

Table 1.6

Student's learning satisfaction

Sl No.	Variables	Mean ()	SD	Level of opinion
1	Interest	4.38	0.66	High
2	Participation	4.40	0.68	High
3	Satisfaction	4.33	0.71	High
Average Total	4.37	0.68	High	

Discussion

The major conclusion drawn from this study, as shown in Table 1.7, is that according to the pre-test result data in the achievement test, there is no significant difference between the experimental and control groups, which means the two groups were highly similar to each other in terms of their academic performance.

In the post-test, the resulting data showed that there was a significant difference between the experimental and control groups. The experimental group, after the engagement with multimedia, performed better than the control group which did not receive the same resources.

Table 1.7

Pre-test and post-test result comparison between two groups

Pretest	Post-test				
Group	N	Mean ()	SD	Mean ()	SD
Experimental	35	9.86	1.517	20.54	1.540
Control	35	9.83	1.706	9.97	1.200
Difference		0.029	1.978	10.571	2.140
t - value	0.932	0.000			

For the experimental group, it was observed that all students were in the learning process, while control group students could not be addressed as a whole. This means that the use of multimedia resources could engage more students in the learning process. This way, all students in a classroom could be addressed. In the control group, on the other hand, traditional instruction had little or no effect on the

level of academic achievement of the students. It was concluded that students in the control group perhaps had greater difficulties in understanding abstract topics and this made their learning process harder. It is significant that the resources used in the experimental group were more attention-catching and apparently enjoyable than the ones used in the control group.

Furthermore, overall analysis of the questionnaires revealed a positive response about the learning satisfaction obtained by using multimedia resources. The students in the experimental group were more satisfied with learning chemistry with the integration of multimedia in the teaching-learning process. The use of multimedia resources enhanced the classroom interaction among students and between the teacher and the students. The results demonstrate that the students enjoyed learning and displayed a high level of confidence in understanding the learning concepts.

The conclusion could be made that the use of multimedia resources in the teaching and learning process helped increase students' academic performance, motivation, and positive attitudes towards this science subject.

Recommendation

Every good teacher wants to find better ways to motivate students and inspire quality learning in the classroom. Understanding how students learn is a crucial step in providing a quality education, offering them different opportunities to draw upon their multiple intelligences is an excellent way to ensure quality learning. A teaching model employing multimedia resources was applied in this research, which showed positive enhancement, regardless of the type of lesson. The use of such learning opportunities could certainly empower students and give them the chance to develop the self-confidence, knowledge, and skills necessary to survive in this Information Age and to inspire them to become life-long learners (Jiang & Rafeeq, 2019).

In addition, this study could help teachers and students to promote the use of multimedia resources in teaching and learning. In the light of the findings of the present study, the following recommendations are made for the general improvement of student's academic performance:

- Integrate multimedia resources in lessons to stimulate discussion and critical thinking of the students during the presentation of the new material.
- Expand the use of multimedia resources in different teaching subject areas and stress the importance of the use of a computer as an educational tool in teaching.

- Incorporate a variety of multimedia tools like simulations, slides, animations, photographs, and voice recordings in lessons to make the topics more interesting and interactive.
- Engage students more fully into the learning process by enabling them to prepare some multimedia resources of their own (slides, Internet searches, etc.).
- To understand the true impact of this instructional method and to get more robust results, further research should be done over an extended period.
- Conduct more research on using multimedia resources across the whole academic curriculum.

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