International Research Journal of Social Sciences and Humanities, Vol.:03, Issue: 01,Jan-June,2024
PP:803-812

OPEN ACCESS
IRJSSH
ISSN (Online): 2959-1392
ISSN (Print): 2959-2887
www. irjssh.com

DEVELOPMENT AND VALIDATION OF RESEARCH INSTRUMENT TO ASSESS THE IMPACT OF TEACHING CHEMISTRY VIA ANIMATED VIDEOS

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Abstract

This study investigates the impact of using animated videos as a teaching tool in secondary-level chemistry education, focusing on students' learning outcomes and motivation. Traditional teaching methods often fail to engage students or explain complex chemical concepts adequately. With their dynamic and visually appealing content, animated videos offer a potential solution to these challenges. The research employs a quasi-experimental design, comparing students' performance and motivation levels using animated videos against those taught via traditional teaching methods. Data was collected through pre-and post-tests, as well as motivation surveys (google form). The research population (N=500) was divided into experimental (N=250) and control (N=250) groups from 20 secondary schools of District Mandi Bha Uddin. The findings reveal a significant improvement in the learning outcomes and motivation of students exposed to animated videos. Specifically, students demonstrated better retention of knowledge, higher levels of understanding of abstract concepts, and increased motivation toward chemistry. This study underscores the efficacy of animated videos in enhancing both educational achievement and student engagement in secondary-level chemistry, suggesting their broader application in science education. The animated videos had both visual-pictorial and auditory-verbal capabilities. This and the fact that students were engaged in active learning can explain the positive and high correlation between thinking skills and motivation to learn chemistry among the experimental students.

Keywords: *animated videos, chemistry learning otcomes,*

motivation, thinking skills.

INTRODUCTION

In recent years, the educational landscape has witnessed a significant transformation, with innovative teaching methodologies reshaping how subjects are taught and learned. Among these advancements, the integration of animated videos into the teaching of chemistry at the secondary level stands out as a particularly promising approach. Traditional methods of instruction, often characterized by dense textbooks and static lectures, can sometimes fail to engage students or effectively convey complex scientific concepts. Animated videos, however, offer a dynamic and visually engaging alternative that can enhance students' understanding and retention of material.

This article explores the impact of teaching chemistry through animated videos on students' learning outcomes and motivation at the secondary level. By leveraging the power of visual storytelling and animation, educators can create a more interactive and stimulating learning environment. Through a comprehensive analysis of recent studies and educational practices, we aim to uncover the extent to which animated videos can transform chemistry education, fostering a deeper comprehension and a heightened enthusiasm for the subject among secondary school students. This research is grounded in the cognitive theory of multimedia learning, which posits that learners can achieve better understanding when information is presented in both visual and verbal forms (Mayer, 2009). The outcomes of this study are expected to provide insights into the effectiveness of animated videos as a teaching tool in secondary chemistry education, potentially guiding future pedagogical strategies and resource allocation.

By examining both teachers' attitudes and students' learning outcomes, this study seeks to contribute to the broader discourse on educational innovation and the optimization of teaching methods to enhance student achievement and engagement in science education.

LITERATURE REVIEW

The use of animated videos in teaching chemistry has garnered significant attention due to its potential impact on students' learning outcomes and motivation. This review synthesizes current research to explore how animated videos influence secondary-level students in these domains.

Research indicates that animated videos can enhance students' understanding of scientific concepts. A study by Barak, Ashkar, and Dori (2011) found that students who used animated movies in their science classes demonstrated improved explanation abilities and a deeper understanding of chemistry concepts compared to a control group. The study involved 1,335 students, divided into experimental and control groups, and used pre-and post-tests to measure learning outcomes. The findings showed that animated videos help students by engaging multiple learning styles

(visual, auditory, kinesthetic), making complex concepts more accessible.

In terms of motivation, the same study by Barak et al. (2011) revealed that students exposed to animated videos showed higher levels of self-efficacy, interest, and enjoyment in learning chemistry. These students were more likely to see the relevance of chemistry to their daily lives and future careers, thus fostering a more intrinsic motivation to learn the subject. The multimedia nature of animated videos, which combines visual and auditory stimuli, was particularly effective in maintaining student engagement and interest.

Other studies support these findings. Research published in "Computers & Education" highlighted that animations can reduce misconceptions and promote meaningful learning when designed correctly. Another study emphasized that the interactive elements of animated videos encourage active learning, which is crucial for understanding complex scientific phenomena.

POPULATION AND SAMPLE

The study targets secondary school chemistry teachers and their students from District Mandi Baha Uddin who integrated animated videos into the chemistry curriculum of 9th and 10th grade students. The total population for this research comprises 500 participants, including both teachers and students. The sample selection is done through stratified random sampling to ensure representation from various secondary schools. The research population included 500 students. The experimental group included 250 students from five high schools (9th graders: N=200 and 10th graders: N=50). The control group included 250 students from two high schools (9th graders: N=200 and 10th graders: N=50). Gender distribution was close to even (50.3% girls), 11.3% declared that their parents' occupation involves a scientific field (medical doctors, scientists, engineers, etc.), and 12.8% declared that they participated in extracurricular activities in science education. Pearson Chi-Square test indicated no statistically significant differences between the research groups in respect to gender distribution, class, parent's occupation, and extracurricular activities distribution.

RESEARCH OBJECTIVES

- *To Evaluate the Effectiveness of Animated Videos in Teaching Chemistry.*
- *To Measure the Influence of Animated Videos on Students' Learning Outcomes.*
- *To Investigate the Role of Animated Videos in Enhancing Students' Motivation.*
- *To Identify Best Practices for Integrating Animated Videos in Chemistry Curriculum*

RESEARCH QUESTIONS

- *Assess the impact of animated videos on students' learning of chemistry concepts compared to traditional teaching methods.*
- *Determine how animated videos affect students' academic performance in chemistry.*
- *Explore whether animated videos increase students' motivation and interest in learning chemistry.*

DATA COLLECTION METHODS AND TOOLS

A structured questionnaire is developed to gauge teachers' attitudes, beliefs, and perceptions regarding the use of animated videos in teaching chemistry. The survey includes Likert scale questions, open-ended questions, and demographic information. The research was based on the quantitative methodology using the pre-post-experimental design (Campbell & Stanley 1963; Kerlinger, 1973). The teaching/learning method (the integration of animations) was the independent variable, while the dependent variables were: students' thinking skills: understanding, implementation (lower order thinking skills) and reasoning (higher order thinking skills); students' motivation to learn science; and, students' overall achievement in chemistry. Our study included two questionnaires: a. Science thinking skills and b. Motivation to learn science.

Experts in chemistry education validated both questionnaires. Expert opinion was solicited from 40 experts. 10 items were removed due to poor content validity (CVR < 0.45). The reliability, determined by internal consistency, Alpha Cronbach was 0.88 for the Motivation questionnaire. Kuder Richardson KR-20 for assessing the reliability of dichotomy scales indicated 0.72 for the Science thinking skills questionnaires. The grades examined students' overall achievement in chemistry in their report cards at the end of the academic years 2023-2024.

RESEARCH SETTINGS

The research included three stages: A. a pilot study that was conducted to establish the research tools' reliability and validity, B. the main study, and C. data analysis and writing the final report. The main study included twenty high schools from the district of Mandi Bah Uddin. The schools were divided into experimental and control groups according to the head and chemistry teachers' preferences. The experimental schools integrated web-based animations created by ChemTube3D (https://www.chemtube3d.com/) into their chemistry curriculum. The control schools continued traditionally teaching chemistry courses – using books and worksheets with static 3D animated videos. Teachers from both research groups were experienced in teaching chemistry. ChemTube3D website provides three to five-minute animated

videos that entertainingly explain hundreds of scientific concepts. Each video includes animated characters who lead users through educational activities, including an interactive quiz, an experiment, and a printable activity page. The teachers' section contains lesson plans and ideas for using Chem Tube 3D in the classroom. As part of our study, both the science thinking skills and the motivation to learn science questionnaires were administered before and after learning with ChemTube3D animations – at the beginning and the end of the school year 2023-2024.

DATA ANALYSIS

Exploratory and confirmatory data analysis was done by using SPSS software. Descriptive statistics were used to summarize the survey data, including mean scores, standard deviations, and frequency distributions. Techniques such as t-tests and ANOVA were applied to determine if there were statistically significant differences in students' learning outcomes and motivation before and after the use of animated videos. The reliability, determined by internal consistency, Alpha Cronbach was 0.88 for the Motivation questionnaire. Kuder Richardson KR-20 for assessing the reliability of dichotomy scales indicated 0.72 for the Science thinking skills questionnaires.

RESULTS

Quantitative analysis reveals a statistically significant improvement in students' understanding of chemistry concepts following exposure to animated videos. Pre- and post-assessment scores demonstrate a notable increase in academic achievement among students who engaged with animated video content. Furthermore, qualitative data from surveys (google form questioner) of chemistry teachers attributed to the dynamic and visually stimulating nature of animated videos. The following section includes three parts. Each part provides an answer to one of the research questions.

THE EFFECT OF ANIMATED VIDEOS ON STUDENTS' THINKING SKILLS: COMPREHENSION, PRODUCTION, AND EVALUATION

Analysis of the pre-and post-questionnaires indicated a statistically significant difference between experimental and control group students ($F=127.50$, $p<0.001$). We found that the only difference in students' gain in 'science thinking skills' is explained by their participation in the ChemTube3D animations, and not by gender, class, parents occupation, or participation in extracurricular activities. In other words, students who experienced the use of ChemTube3D animated videos as part of their chemistry learning developed thinking skills, such as: science understanding and knowledge implementation, better than their peers in the control group. Eta Squared analysis indicated that 9.3% of the growth in students' science thinking skills can be explained by their use of animated videos.

The comparison of 9th and 10th grade students' levels of explanations showed that the experimental group students (in both class cohorts) had a higher percentage of correct explanations compared to the control group students. These differences were statistically significant among the 9th grade students ($F_{(250)}$=7.10 p<0.05).

THE EFFECT OF ANIMATED VIDEOS ON STUDENTS' MOTIVATION TO LEARN CHEMISTRY

Table.1 compares experimental and control groups on pre- and post-questionnaire categories and general motivation

Table 1. Students' motivation to learn science – experimental versus control, by category Pre-questionnaire Post-questionnaire

Category	Research group	Mean	Std. Dev.	Mean	Std. Dev.	F	p<
Experimental Self-efficacy		3.21	1.03	3.66	0.96	8.17	.001
	Control	3.16	0.87	3.41	0.97		
Interest and enjoyment	Experimental	3.75	1.28	4.14	0.99	8.04	.001
	Control	36	1.05	3.67	1.09		
Connection to daily leaving	Experimental	3.16	1.06	3.78	0.91	5.51	.001
	Control	2.93	0.86	3.37	0.95		
Importance to the student	Experimental	3.64	1.11	4.15	0.87	3.85	.001
	Control	3.25	1.02	3.50	0.92		
General Motivation	Experimental	3.45	0.98	3.95	0.77	3.49	.001
	Control	3.17	0.75	3.53	0.79		

Table.1 also shows that students who used the animated videos of ChemTube3D became more interested in learning chemistry (in all categories) than the controls.

Table 2. Correlation between Students' motivation to learn chemistry andtheir thinking skills enhancement

Research group	Variable	N	Mean	Std. Dev.	r	p<
Experimental	Motivation	50	0.57*	1.14	0.22	0.001
	Thinking skills	00	13.72**	27.36		
Control	Motivation	50	0.36*	0.84	0.12	0.05
	Thinking skills	00	5.56**	25.70		

** On a scale of 5 ** On a scale of 100*

Table.2 show that in both research groups (experimental and control)

statistically significant correlations were found between students' gain in motivation and their thinking skills. However, the correlation between the two variables (motivation and thinking skills) in the experimental group was almost twice as high compared to the control group.

IMPACT OF ANIMATED VIDEOS ON STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY AS EVIDENCED ON THEIR REPORT CARDS

The comparison of experimental and control students' grades in science as reflected in their final report cards (Figure.1) indicated that students from both groups received similar grade in chemistry at the beginning of the session 2024 (around 81.5), but received lower means at the middle of the session 2024. This can be explained due to a more severe grading system as the students matured.

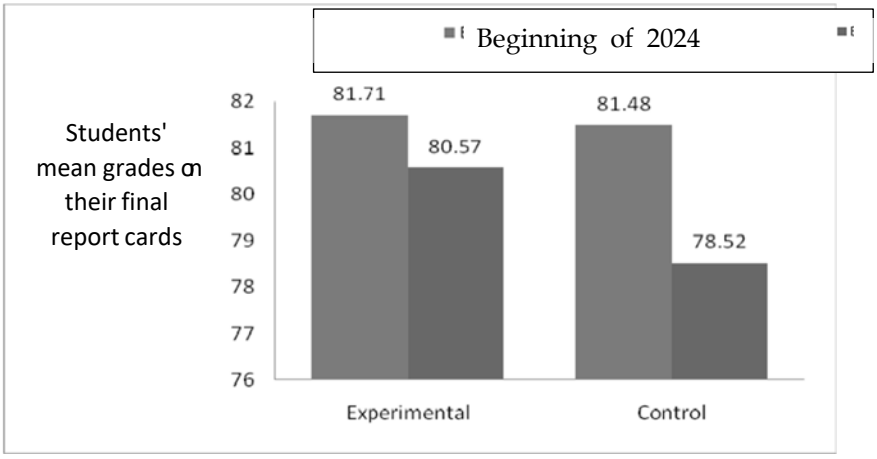

FIGURE 1. AVERAGE GRADES IN FINAL REPORT CARDS FOR EXPERIMENTAL AND CONTROL STUDENTS

Students using ChemTube3D for their chemistry education achieved significantly higher grades on their report cards at a rate of 91% ($F(500) = 2.74$, $p = 0.09$).

DISCUSSION

The findings of this study align with existing literature on the benefits of multimedia in education. Research indicates that multimedia learning aids, such as animated videos, cater to various learning styles and enhance cognitive processing by providing visual and auditory stimuli (Mayer, 2009). Additionally, the dual coding theory suggests that combining verbal and visual information can improve memory and understanding (Paivio, 1986).

Despite the positive outcomes, some challenges were noted. A small fraction of

teachers (12%) expressed concerns about the potential over-reliance on animated videos, which might diminish students' ability to learn from traditional text-based resources. Furthermore, the need for adequate training and resources to effectively integrate animated videos into the curriculum was highlighted as a critical requirement.

SUMMARY AND RECOMMENDATIONS

Some researchers suggest that animated videos can lead to the development of misconceptions and impede meaningful learning (Schnotz & Rasch, 2005). On the contrary, the results of this study and other research (Dori & Belcher, 2005; Rosen, 2009) demonstrate the opposite effect. Our research reveals that the use of animated videos improves students' critical thinking skills in chemistry comprehension, knowledge application, and reasoning capacity. Since reasoning ability is crucial for establishing logical relationships, students exposed to animated movies exhibited fewer misconceptions compared to their peers in the control group. Additionally, our study indicates that students who learned chemistry through animated videos showed greater motivation to learn the subject, as evidenced by increased self-efficacy, interest and enjoyment, relevance to daily life, and perceived importance for their future, in contrast to students who followed traditional science instruction

Mayer's cognitive theory (2002) posits that knowledge is encoded and processed through two cognitive pathways: visual-pictorial and auditory-verbal. The animated movies in our study possessed both visual-pictorial and auditory-verbal elements. The active engagement of students in learning activities can account for the strong positive correlation between critical thinking skills and motivation to learn science observed among the experimental group. Additionally, this active learning approach likely contributed to the higher science grades seen in the students' report cards compared to those who followed traditional study methods.

Given the promising outcomes detailed in this study, we propose to encourage educators across various disciplines (including science, English, Literature, etc.) to incorporate animated videos, along with other educational activities recommended on the website, more frequently - surpassing a weekly occurrence. Additionally, we advocate for the development of more animated content tailored for older audiences, targeting high school and university students. Leveraging the website as a platform, we suggest fostering communities of learners comprising both teachers and students in Israel and globally.

It is widely acknowledged "a picture is worth a thousand words." Building upon the positive findings of the research, we posit that "an engaging animated movie is worth a thousand pictures."

The study concludes that the integration of animated videos in teaching chemistry at the secondary level positively influences both student learning outcomes and motivation. It suggests that educational policymakers and school administrators should consider promoting the use of animated videos as a pedagogical tool, providing necessary resources and training for teachers to effectively implement this technology in their classrooms.

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