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RESEARCH PAPER

Impact of Computer-Generated Imagery Animation on Pupils' Performance in Biology at Secondary Level

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ABSTRACT

The paper aimed to examine the impact of computer-generated imagery (CGI) animation on the performance of secondary school children in Biology. The objectives were to compare the academic performance of students taught via CGI animation versus traditional methods, across various cognitive levels. Science and technology are key drivers of sustainable development, essential for economic and social progress through understanding natural phenomena. The study focused exclusively on 9th class Biology students in a Govt Girls high school, Gujranwala, using 2D and 3D CGI animation presentations during the 2024-25 session, over four weeks. The experimental study used a "Pretest-Posttest Equivalent Groups Design" to assess CGI animation's impact on Biology performance through a 30-MCQ-based Biology Performance Test covering six cognitive levels (knowledge, comprehension, application, analysis, synthesis, and evaluation. The research instrument was validated by experts and confirmed reliable with a 0.831 coefficient using the test-retest method for accurate study results. The experimental group was taught through the CGI animation technique, whereas the control group was taught through the traditional teaching method. On the completion of four weeks' experimental process, posttest was planned immediately to examine the level of pupils' achievement of both groups. Statistical tools such as mean, standard deviation and independent samples t-test were employed for analyzing data. The results showed that CGI animation significantly positively impacted pupils' performance in Biology. Based on the findings, it was recommended that science teachers should use the CGI animation technique to stimulate and boost pupils' performance in Biology at the secondary level.

KEYWORDS Animation, Biology, Performance, Pupil, Secondary Level, Traditional Teaching Method

Introduction

The crucial role of science and technology in a nation's sustainable development cannot be overstated (Ong et al., 2024; Shafqat & Amjad, 2024). Both economic and social progress in countries like Pakistan heavily rely on the scientific and technological literacy of their citizens. Every branch of science contributes significantly to technological advancement, serving as the foundation for understanding and explaining natural phenomena. Ezechi and Adukwu (2018) asserted that a nation's technological progress depends on robust science education, indicating that to achieve technological advancement, priority must be given to promoting scientific knowledge across all educational levels. Olayiwola (2014) highlighted that science has become a key component of the secondary school curriculum globally, laying the groundwork for further studies in higher education.

Computer animation enhances instructional processes by engaging students and clarifying complex concepts by incorporating graphics, text, video, sound, and images

(Tabbasam et al., 2023; Tabassum et al., 2024). Bamidele and Yoade (2017) defined it as simulated motion pictures stimulating student interest and concretizing abstract ideas. According to Owolabi et al. (2019), computer animation combines audio and visual elements to support learning, reducing the time required for mastery and improving retention. Gambari, et al. (2014) noted that multimedia animations capture students' attention and boost motivation, making Biology more engaging and comprehensible. Abanikannda (2018) emphasized that Biology explains the structure, function, and interaction of living things with their environment.

The concept of 'academic achievement' has been defined in various ways, but it consistently reflects the extent to which predetermined educational objectives are met, typically measured by grades or scores (Qureshi et al., 2023). Ikwuka and Samuel (2017) described academic achievement as the outcome of education, indicating how well students, teachers, or institutions meet their educational goals, usually assessed through examinations or continuous assessments. It encompasses the knowledge and skills acquired through learning experiences, determined by test and exam results. Similarly, Ouma and Munyua (2018) defined academic achievement as the degree to which students achieve educational goals, also measured by examinations or assessments. For this study, academic achievement refers to the total scores obtained by students on tests.

In Punjab's district of Gujranwala, secondary schoolchildren consistently underperform in biology exams, likely due to traditional teaching methods that fail to engage and motivate. This raises the need to explore whether Computer-Generated Imagery (CGI) animation can enhance academic performance by making biology more interactive and accessible. The problem statement was "Impact of Computer-Generated Imagery (CGI) Animation on Pupils' Performance in Biology at Secondary Level."

Literature Review

The present part provides a specific review of literature focused on the effectiveness of CGI animation techniques on pupils' education achievement (Amjad et al., 2023, a, b c). CGI animation is increasingly being recognized as an effective educational tool. In Pakistan, several studies have explored its potential to enhance learning experiences, particularly in the field of science in higher education. CGI animations can simplify complex scientific processes, making them more accessible and engaging for pupils (Amjad & Malik, 2024).

Over the past two decades, animation emerged as an essential feature of technology-enhanced learning (Amjad et al., 2024, a, b, c). The instructional animations were crafted for classrooms, educational TV, and other settings to present information in an engaging manner (Musa et al., 2015). Many countries supported animation as a student-centered alternative to traditional methods. Animation excelled in illustrating concepts with temporal changes by making abstract ideas concrete (Rias & Zaman, 2011). Some researchers highlighted that animations provided mental simulations, enhancing cognitive processing (Bada et al., 2012).

Gupta and Lata (2014) discovered that animation significantly enhanced student achievement in science compared to traditional lecture methods. Ogundokun and Adeyemo (2010) attributed low academic achievement to the reduced availability of teaching resources in schools. Yegoh et al. (2016) emphasized that academic achievement, along with its predictor retention and interest, had been a key concern for educational researchers and policymakers for many years.

Many studies examined the impact of CGI animations on secondary school students' understanding, revealing a significant improvement in achievement scores enhanced student engagement and comprehension, leading to better retention and increased interest for those taught with animations compared to traditional methods (Ahmad et al., 2023). Some research focusing on cognitive benefits showed that CGI animations improved students' academic performance and critical thinking, with teachers noting higher enthusiasm and participation. Long-term effects of CGI animations were also explored, demonstrating sustained achievement and knowledge retention over an academic year. These findings collectively supported the effectiveness of CGI animations in education (Stavreva & Stavreva, 2020).

Animation proved to be a powerful tool for engaging audiences in an enjoyable and innovative manner, impacting fields from education to marketing. This review systematically examined the influence of animation on viewers' visual attention, based on publications from Google Scholar, Science Direct, Taylor & Francis, and IEEE Xplore between January 2015 and December 2021. Out of 175 titles, 114 full articles were analyzed, with 35 focusing on visual attention. The studies assessed physical, psychological, and cognitive outcomes, revealing that animation enhanced visual attention through varied stimuli and organized presentation, improved conceptual understanding, and supported learning and marketing. The review also addressed study limitations, future recommendations, and emerging areas such as data visualization, smart communication, and 3D modeling (Praveen & Srinivasan, 2022).

Overall, the reviewed studies collectively indicated that CGI animations were highly effective in improving students' performance in their studies. While existing research shows CGI animations enhance academic performance, gaps remain in understanding their academic achievements in biology and impact on various cognitive levels. Further studies are needed to explore these aspects comprehensively and determine optimal integration strategies for sustained educational benefits. However, existing literature primarily addresses the effects of computer animation on students' interest and academic achievement in various subjects, with less focus on biology in Pakistan.

Hypotheses

Ho1: There might be no substantial contrast between the academic performance of pupils of control and experimental groups on pre-test.

Ho2: There might be no substantial contrast between the academic performance of pupils who were taught through CGI animation and those who were taught through traditional method on post-test.

Ho3: There is no substantial contrast in pupils' performance of experimental and control groups in different levels of cognitive domain i.e., knowledge, comprehension, application, analysis, synthesis and evaluation on post-test.

Material and Methods

The current study was experimental type that seeks to examine the impact of CGI animation on the performance of pupils in subject of Biology. Due to experimental nature, "Pretest-Posttest Equivalent Groups Design" was used to achieve the required outcomes.

All the girl high school pupils studying in public secondary schools in Gujranwala District constituted the study population. A sample of 60 girl pupils of class ninth was selected through simple random sampling technique from Government Girls High School Gujranwala. The participants were similar with respect to a number of characteristics i.e., age, sex, locality, socioeconomic status etc. The participants were separated into control and experimental groups based on pretest outcomes. Biology Performance Test was used as research instrument comprising of six levels of cognitive domain i.e., knowledge, comprehension, application, analysis, synthesis and evaluation. The test was developed in two units of Biology taught during the experimentation. The units were; Introduction to Biology and Solving a Biological Problem. There were total 30 MCQs in the said achievement test carrying 60 marks in total. Each level of domain was comprised of 05 MCQs.

To confirm validity and reliability of research instrument was crucial for precise and authentic outcomes of the study. Without confirming validity and reliability of the instrument, conduction of research was useless and timewasting. Therefore, after developing performance test, it was properly validated through experts having doctorate degrees in the relevant field. Apart from validity, reliability was confirmed through test retest reliability technique. The reliability coefficient was found 0.831 which showed that the test was reliable.

Before conduction of experimental, formal approval was sought from the head of school where experimentation was to be done. After getting permission, experimental process was started. Pupils of control group were taught through traditional teaching method while pupils of experimental group were taught through CGI animations. The experimental process was completed in four weeks. Then a posttest was given to the pupils of both groups immediately to examine their academic performance.

Results and Discussion

The study was experimental and pre-test post-test equivalent groups design was used for data collection. After completion of experimental process, raw data was organized, tabulated and analyzed based on descriptive as well as inferential statistics i.e., mean, standard deviation and t-test. Statistical process was described as under:

Table 01
Independent-Samples t-test Analysis of the Academic Performance scores of Experimental & Control Groups on Pretest

Groups	N	Mean	SD	SEd	Mean Difference	t-value	p-value
Control	30	71.62	4.93	1.42	0.11	0.0770	0.939
Experimental	30	71.51	4.73				

The inferential analysis of Table 1 showed no significant difference ($p>0.05$) between the experimental and control groups' performance on the pretest, as the calculated t-value was smaller than the tabulated t-value at the 0.05 level. Additionally, the mean values clearly indicated that the experimental group (mean = 71.51, SD = 4.73) performed slightly better than the control group (mean = 71.62, SD = 4.93). Therefore, the null hypothesis was accepted.

Table 2
Independent-Samples T-test Analysis of the Performance Scores of Experimental and Control Groups on Posttest

Groups	N	Mean	SD	SEd	MD	t-value	p-value
Control	30	74.37	9.81	2.46	23.70	9.618	0.000

Experimental	30	98.08	6.57

The results of Table 2 showed a significant difference ($p<0.05$) between the experimental and control groups' performance on the posttest, as the calculated t-value exceeded the tabulated t-value at the 0.05 level. Additionally, the mean values clearly indicated that the experimental group (mean = 98.08, SD = 6.57) outperformed the control group (mean = 74.37, SD = 9.81). Therefore, the null hypothesis was rejected.

Table 3
Inferential Analysis of Performance of Pupils of Experimental and Control Groups in Different Level of Cognitive Domain

Levels of Cognitive Domain	Control Group		Experimental Group		t-value	p-value
	Mean	SD	Mean	SD		
Knowledge	15.38	7.21	16.03	5.67	0.340	0.736
Comprehension	11.84	7.23	16.08	6.37	-2.110*	0.041
Application	12.81	6.81	17.23	5.39	-2.441*	0.019
Analysis	10.55	6.96	15.07	5.74	-2.403*	0.013
Synthesis	10.83	7.34	15.85	5.64	-2.601*	0.013
Evaluation	12.98	4.39	17.83	4.98	-3.504*	0.001

Table 3 indicated that the calculated t-values for the five cognitive levels were -2.110, -2.441, -2.403, -2.601, and -3.504, all of which were significant ($p<0.05$), as they exceeded the tabulated t-value at the 0.05 level. Thus, the null hypothesis was rejected. The mean values clearly showed a significant difference between the performance of the control group (mean = 11.84, 12.81, 10.55, 10.83, and 12.98) and the experimental group (mean = 16.08, 17.23, 15.07, 15.85, and 17.83) across the five levels of the cognitive domain comprehension, application, analysis, synthesis, and evaluation on the post-test. It was concluded that the experimental group performed better in these five cognitive levels compared to the control group. However, no significant difference was found between the two groups in the knowledge domain.

The study was conducted to explore the impact of CGI animations on pupils' performance in Biology at secondary level. The study was quantitative and experimental in nature and pretest-posttest equivalent groups designed was used. Pupils were seated in two similar rooms with similar facilities. The room of experimental group was facilitated with computer, multimedia and other related gadgets. Pupils of experimental groups were instructed through CGI animations while pupils of control group were taught through traditional method. This experimental process was ended in four weeks. After completion of experiment, pupils of both groups were subjected to posttest in order to investigate and compare their academic performance. The findings exposed that pupils of experimental group were found more interested, excited, satisfied and participated as compared to the pupils of control group who were found exhausted and bored. It means that CGI Animations was an effective and successful method contributing to pupils' performance in subject of Biology generating high scores.

Based on interferential analysis of academic performance of experimental and control groups in different level of cognitive domain on post-test, the study outcomes revealed that pupils of experimental group showed superiority over the pupils of control group in five levels of cognitive domain i.e., comprehension, application, analysis, synthesis and evaluation whereas in case of knowledge, no substantial difference was found between the academic performance of both groups. However, it clearly indicated that CGI animations instruction was very effective in different level of cognitive domain. The findings of the current study supported the findings of Hamzat and Abimbola (2017) who founded that animation was significantly more viable than traditional teaching in learners' achievement in physics. The findings of the study were in line with the findings

of many researches outcomes in which it was founded that animations had positively affected learners' perceptions about computer supported instruction and their scholastic accomplishment (Bamidele & Yoade, 2017; Etobro & Fabinu, 2017 ; Nnorom & Emeka-Ifeanyi, 2024)

Conclusions

The findings demonstrated that CGI animation significantly improved students' academic performance in secondary-level Biology, proving more effective than traditional teaching methods. It was particularly beneficial across various cognitive domains, such as comprehension, application, analysis, synthesis, and evaluation, while showing no substantial difference in the knowledge domain. CGI animations helped clarify complex topics, making learning more engaging and enhancing understanding. Pupils in the experimental group were more enthusiastic and performed better than those in the control group, who showed less interest and lower scores. Overall, CGI animation emerged as a powerful tool for boosting academic outcomes and positively influencing pupils' perceptions and learning experiences in Biology.

Recommendations

It is recommended that science teachers in Pakistan, adopt CGI animation as a core instructional method, replacing traditional approaches. This strategy will simplify complex topics, enhance student engagement, and improve academic performance. Teachers should receive specialized training in effectively utilizing CGI animations and related technologies in their classrooms. Furthermore, secondary schools must prioritize equipping classrooms with computers, multimedia tools, and other necessary gadgets to support this modern teaching approach. Regular workshops should be held to update teachers on the latest CGI-based instructional techniques. Incorporating CGI into teacher training institutes will also ensure that future educators are well-prepared to integrate these innovative methods. This shift in teaching strategies will improve the quality of science education, fostering critical thinking, deeper understanding, and active student participation in studies. Overall, implementing CGI animation in science education will contribute significantly to building a scientifically literate generation capable of addressing future challenges.

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