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Evaluation of The Flipped Classroom Model on Students' Academic Achievement and Retention in MAN 1 Ambon

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Abstract

This study assesses the impact of computer simulation and animation instructional packages in natural sciences on high school student's academic achievement and retention within a flipped classroom setting. Employing a quasi-experimental pre-test and post-test design, 30 students engaged with the computer simulation package, while 29 students utilized the computer animation package. Data collected via academic achievement and retention tests were analyzed using descriptive statistics and independent sample t-tests. The results showed significant improvements in educational attainment for both groups. The average post-test score increased from 28.52 to 70.35 in the computer simulation group and 25.74 to 64.23 in the computer animation group. The t-test results indicated no significant difference in academic achievement between the two groups ($t = 1.98$, $p = 0.79$). Although retention scores showed a slight decrease from the post-test to the retention test, they remained high, with average retention scores of 68.74 for the simulation group and 61.15 for the animation group. The t-test also revealed no significant difference in retention between the groups ($t = 1.12$, $p = 0.66$). The implications of this study suggest that employing educational technology, such as computer simulations and animations, in a flipped classroom setting can significantly enhance students' academic achievement and knowledge retention. It underscores the importance of integrating technology into the educational curriculum to foster a more inclusive, interactive, and practical learning environment. Moreover, these findings allow educators to select the teaching methods that best align with their instructional needs and contexts, whether in resource-limited settings or when addressing complex concepts.

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INTRODUCTION

Technology integration into education has revolutionized traditional teaching and learning methods, introducing innovations and skills that enhance and complement existing practices (Joshi, 2023; Mandal & Srinivas, 2022). The adoption of technology in education fosters a more diverse and interactive learning environment, enabling the use of various instructional strategies (Kostashchuk & Bilenkova, 2022; Wang, 2023). Deploying digital tools, including online learning platforms, educational apps, and interactive software, is crucial in enriching the learning experience (Priyadarshini et al., 2023; Yusuf et al., 2023). This transformation creates a more inclusive, technology-driven learning setting, significantly boosting student engagement (Appova et al., 2022; Susilo et al., 2023) and deepening students' understanding of the material (Nafia et al., 2023). Educational technology allows for personalized learning experiences, enabling students to study at their own pace and in ways that enhance both cognitive and non-cognitive outcomes (Yang & Ogata, 2023). Additionally, technology implementation facilitates collaboration and interaction between students and teachers, which were often challenging to achieve through traditional methods (Shamansurovna et al., 2023).

Furthermore, the role of education is to explore physical and social phenomena, foster individual growth, and drive career advancement, requiring the adoption of more innovative teaching methods (Horbatiuk et al., 2023). Issues such as a shortage of qualified teachers and reliance on outdated teaching practices highlight the critical need to incorporate more dynamic, student-centered approaches (Petrova et al., 2023). This shift necessitates creating technology-integrated curricula, enhancing teachers' proficiency with modern technological tools, and adapting teaching strategies to align with the demands of the 21st century (Shkerina et al., 2022). Education cultivates competitive and innovative individuals (Ahmad et al., 2023), sharpens teachers' skills, and elevates student learning outcomes (Singh, 2023; Slyusarenko et al., 2022). It prepares students to tackle future professional challenges by improving teaching quality through ongoing training and boosting learning efficiency with contemporary technology (Asegu, 2023; Kizi & Barnokhon, 2022; Mitina, 2022). Ultimately, education is essential for personal and professional growth, equipping individuals to become productive, responsible members of society (Hübel et al., 2023).

Despite various innovations in education, the primary challenge remains the effective integration of technology to enhance academic achievement and student retention. Traditional teaching methods often need to sufficiently engage students or facilitate the mastery of complex concepts (Rahmat et al., 2023; Valverde-Berrocoso et al., 2022; Yesgat et al., 2023). Incorporating technology, such as computer simulations and animations, has been proposed to address these challenges, yet the effectiveness of each method within the educational context still requires further investigation (Bhat, 2023; Gordillo-Tenorio et al., 2023). In this regard, the flipped classroom model presents a promising solution. This approach reverses the traditional teaching model by delivering direct instruction outside the classroom, typically through videos and online materials, allowing educators to allocate class time for more interactive and practical activities (Faloye & Faniran, 2023; Malicay, 2023). The flipped classroom model transforms education by leveraging technology to innovate traditional learning methods (Patero, 2023; Schweiker & Levonis, 2023; Sviridova et al., 2023; Villegas-Ch et al., 2023).

In the flipped classroom model, learners acquire knowledge at home through digital materials such as videos and online readings, preparing them for face-to-face sessions focusing on interactive discussions, collaborative projects, and problem-solving (Cueva & Inga, 2022; Masood et al., 2022). Information and Communication Technology (ICT) plays a crucial role in this process, enabling more effective face-to-face interactions between teachers and students (Campos, 2023; Ramadhani et al., 2022). This approach not only personalizes learning and adapts it to individual learning paces but also increases student engagement, fosters critical and analytical thinking skills, and prepares students for 21st-century challenges (Aidoo et al., 2022; Liu et al., 2023; Sotelo Gomez et al., 2022). The flipped classroom

model enhances students' academic performance and engagement in the learning process while leveraging technology to address challenges related to low or no connectivity (Semab et al., 2022; Xuan et al., 2023).

A wealth of research has firmly established the flipped classroom model as effective in enhancing student performance and retention. Studies have shown increased student performance in descriptive statistics using this model (Atwa et al., 2022; Paramita, 2023; Rayahneh & Al Bataiha, 2022). The use of videos has led to significant improvements in performance and retention compared to using audio and text alone (Palmero et al., 2023). Similar improvements observed with the support of PowerPoint presentations have also increased student engagement and motivation (Falode & Mohammed, 2023; Khaoloek & Chaiyasung, 2022). The flipped classroom approach has yielded positive results across various educational settings (Ali et al., 2022; Meza-Navarro et al., 2022; Ur Rehman, 2022). Researchers have proven the effectiveness of this model in diverse contexts, but questions remain regarding its impact when combined with computer simulations and animations. The increased interactivity and immersion offered by these resources have the potential to enhance student performance and retention further, providing a more profound and more contextual learning experience.

Research has demonstrated that computer simulations and animations enhance learning effectiveness, each playing a crucial role in education. Computer simulations utilize interactive visualizations to facilitate understanding of complex concepts, proving effective in improving student performance and retention (Falode & Mohammed, 2023). For example, studies on genetics have shown that simulations significantly enhance student comprehension (Hamamous et al., 2022). Similarly, computer animations, which combine graphics, audio, and content translation, support students' cognitive processing and reinforce taught concepts (Fang & Guo, 2022). Animations have greatly improved student understanding across various educational topics (Ayasrah et al., 2024). In health education, virtual simulations have effectively developed students' psychomotor skills and knowledge (Cant et al., 2022). Additionally, using animations in teaching biology has been shown to enhance the understanding of abstract concepts (Kaur et al., 2022).

Additionally, simulations have proven effective in teaching physics by enhancing student engagement and understanding (Beichumila et al., 2022). Other studies indicate that simulations can improve students' science process skills (Alam, 2023). Researchers have shown that simulations and animations boost student performance across various educational contexts. (Siregar et al., 2023). Furthermore, research suggests that video animations significantly improve learning outcomes in digital education environments (Ibashova et al., 2022).

These two tools enhance retention and performance while increasing students' interest and motivation, promoting self-directed learning and creative thinking. Integrating computer simulations and animations into educational approaches, such as flipped classrooms, offers a highly effective means of improving education in complex subjects. This approach enriches the academic experience and helps students better understand and retain intricate information. However, existing research often examines the effectiveness of computer simulations and animations separately without considering how these combined methods can be within a single teaching approach. Additionally, in the context of flipped classrooms, further research is needed to explore how the combination of computer simulations and animations can impact academic achievement and student retention in various subjects.

The primary objective of this study is to explore how implementing computer simulations and animations within a flipped classroom setting affects the academic outcomes and knowledge retention of high school students. Specifically, the study aims to (1) assess the impact of computer simulations and animations in a flipped classroom environment on high school students' academic achievement and (2) examine the effects of these tools on students' ability to retain the subject matter. This research is vital as it provides insights into how integrating technology can enhance learning and improve students' understanding and long-term retention of critical subjects in their educational curriculum. It addresses the pressing need to

overcome the limitations of traditional teaching methods, which often fail to engage students and adequately support their comprehension of complex concepts. Education must remain robust in today's digital era, where technology increasingly influences various aspects of life. This research is crucial because it offers a scalable solution to elevate the standard of education, particularly in the instruction of natural sciences. It also contributes to ongoing efforts to equip students with the necessary skills and more profound understanding required for the 21st century by investigating the effective use of computer simulations and animations in a flipped classroom setting.

METHODS

This study employs a quasi-experimental design, incorporating pre-test and post-test evaluations, to investigate the impact of computer simulations and animations in a flipped classroom environment on students' academic performance and knowledge retention. A quasi-experimental design allows researchers to observe changes before and after the intervention in naturally occurring subject groups without strict randomization. In this study, two students will receive different instructional approaches: one group will use computer simulations, while the other will use computer animations within a flipped classroom setting. The study population comprises high school students from MAN 1 Ambon, with a research sample of 126 second-year students. The researchers divide these into two experimental groups: the first group, comprising 30 students, will engage with computer simulations, while the second group, consisting of 29 students, will utilize computer animations. Simple random sampling ensures a fair distribution between the two experimental groups.

This study utilizes three main instruments: the Computer Simulation Instructional Package (CSIP), the Computer Animation Instructional Package (CAIP), and the Academic Performance Test (APT). The developers create the CSIP using Adobe Flash CS6., Action Script 3.0, and the professional software Box2D. Its menu includes a login interface, lesson objectives, a practical interface, and simulation tools. The developers created the CAIP using DigiCel's FlipBook animation software. Its menu features an introductory page, lesson objectives, animated videos, text, and narration. The APT is a 50-item multiple-choice objective test validated by three lecturers from reputable universities. This test has been trialed and shown to have high reliability, with a coefficient value of 0.85, obtained using Pearson's Product-Moment Correlation (PPMC) formula.

Data collection for this study involved pre-tests, post-tests, and retention tests, focusing on two primary indicators: academic achievement and knowledge retention. Researchers administered pre-tests to assess students' initial understanding before the intervention to measure educational achievement. After the students engaged with the instructional packages based on computer simulations and animations, conducting post-tests to evaluate the improvement in their knowledge. Knowledge retention was further assessed by comparing post-test scores with retention scores collected two weeks later, gauging how effectively students retained the material. These metrics measure the effectiveness of technology-based teaching strategies in enhancing students' learning outcomes and their capacity to retain information over time.

The researchers administered the pre-test to students before the intervention to assess their baseline academic performance. Subsequently, students underwent a four-week treatment period during which they learned using the instructional packages specific to their assigned groups. The post-test was conducted immediately after this period to evaluate academic achievement following the intervention. Two weeks later, the researchers administered a retention test to assess how well students retained the material they had learned. The gathered data were analyzed using both descriptive and inferential statistics. Descriptive statistics, such as means and standard deviations, were used to answer research questions concerning students' academic achievement and retention. Inferential statistics, including independent sample t-tests, were applied to test the research hypotheses and assess the significance of differences between the two experimental groups. Data analysis uses statistical software like SPSS to ensure the precision and reliability of the research results.

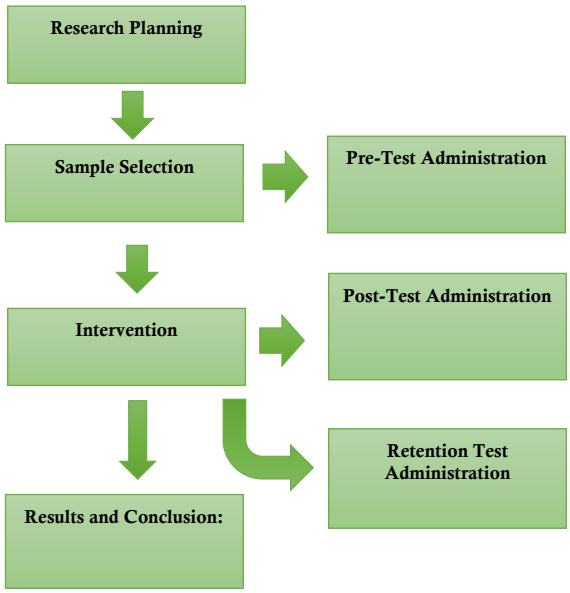

Figure 1. Research Flow Diagram

Figure 1 presents the research flow diagram detailing the main steps and their associated sub-steps. The first step is Research Planning, which includes defining objectives, developing research questions, and selecting the research design and methodology. Next, the researchers conducted Sample Selection, identifying the population, selecting the sample, and randomly assigning participants to experimental groups. After administering the pre-test to evaluate students' initial achievement, a four-week intervention began, during which participants received specific treatments. The researchers then conducted a post-test following the intervention to assess the student's academic performance. The researchers administered a retention test subsequently. To determine how well the students retained the knowledge. The researchers analyzed the collected data using descriptive and inferential statistical methods, with the findings presented in the results and conclusion sections.

RESULTS AND DISCUSSION

Implementing Instructional Computer Simulations and Animations

1. Academic Achievement

This study examines the impact of implementing instructional computer simulations and animations on student's academic performance in a flipped classroom environment. The researchers evaluated the effectiveness of these methods by comparing the pre-test and post-test outcomes, which measured the students' progress in educational achievement. Table 1 presents each experimental group's mean pre-test and post-test scores and standard deviations.

Table 1. Pre-test and Post-test Scores of Students

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Average Gain
Computer Simulation	30	28.52	5.12	70.35	10.48	41.83
Computer Animation	29	25.74	6.45	64.23	14.57	38.49

Table 1 showcases the pre-test and post-test scores of students instructed using computer simulations and animation techniques in a flipped classroom setting. Students who used computer simulations started with a pre-test mean score of 28.52 and a standard deviation of 5.12. After the intervention, their post-test mean score significantly increased to 70.35, with a standard deviation 10.48, reflecting an average improvement of 41.83 points. Meanwhile, students who engaged with computer animations began with a pre-test mean score of 25.74 and a standard deviation of 6.45, achieving a post-test mean score of 64.23, with a standard deviation of 14.57, resulting in an average increase of 38.49 points.

Data analysis reveals that both instructional methods effectively enhance students' academic achievement. The scores indicate that students in both groups experienced significant improvements in their comprehension and academic performance, demonstrating the effectiveness of these teaching approaches. However, while both groups showed progress, the group using computer simulations exhibited a slightly more significant score increase than those using computer animations.

2. Student Retention

This study also evaluates the impact of computer simulation and animation instructional methods on students' knowledge retention in a flipped classroom setting. Retention assessment by comparing post-test scores with retention test scores administered two weeks later to gauge how well students retained the material. Table 2 presents the mean post-test and retention test scores for both experimental groups and their standard deviations. This comparison offers insights into the effectiveness of each instructional method in promoting long-term retention of the subject matter, highlighting the sustained benefits of these teaching approaches.

Table 2. Post-test and Retention Test Scores of Students

Group	N	Post-test Mean	Post-test SD	Retensi Mean	Retensi SD	Average Gain
Computer Simulation	30	70.35	10.48	68.74	9.32	-1.61
Computer Animation	29	64.23	14.57	61.15	11.12	-3.08

Table 2 compares the post-test and retention test scores for students instructed using computer simulation and computer animation methods in a flipped classroom setting. The post-test mean score for the computer simulation group was 70.35, with a standard deviation of 10.48. The retention test mean score slightly decreased to 68.74, resulting in an average decline of 1.61 points. Conversely, students who engaged with computer animations had a post-test mean score of 64.23, with a standard deviation of 14.57, and their retention test mean score dropped to 61.15, reflecting an average decline of 3.08 points. This data suggests that while both instructional methods led to a slight decrease in scores over time, the decline was less pronounced in the group using computer simulations, indicating potentially better knowledge retention in this group.

The results indicate that both groups experienced a slight decline in scores from the post-test to the retention test, suggesting some loss of retained knowledge over time. However, students using computer simulations showed a smaller decrease than those using computer animations, suggesting that knowledge retention is higher among students who use computer simulations.

3. Hypothesis Testing

Hypothesis 1

Hypothesis 1, which examines the difference in average achievement scores among students instructed using computer simulation and animation methods in a flipped classroom setting, is thoroughly detailed in Table 3. This table provides a clear comparison of the performance outcomes for each instructional approach, offering insights into their relative effectiveness.

Table 3. Independent Sample T-test Results of Average Achievement Scores

Group	N	Mean	SD	df	t-value	p-value	Decision
Computer Simulation	30	70.35	10.48	57	1.98	0.79	Accepted
Computer Animation	29	64.23	14.57				

Table 3 presents the independent sample t-test results for the average achievement scores of students instructed using computer simulation and animation methods in a flipped classroom setting. The analysis shows a t-value of 1.98 and a p-value of 0.79. Since the p-value exceeds 0.05, the null hypothesis is accepted, indicating no significant difference in the average achievement scores between the two groups. This outcome suggests that computer simulations and animations are similarly effective in enhancing academic performance in a flipped classroom setting, demonstrating that either method can successfully achieve comparable educational improvements.

Hypothesis 2

Hypothesis 2, which examines the difference in average retention scores among students instructed using computer simulation and animation methods in a flipped classroom setting, is

comprehensively presented in Table 4. This table provides a detailed analysis of how each instructional method impacts students' ability to retain knowledge over time, offering essential insights into the effectiveness of these approaches in promoting long-term learning outcomes.

Table 4. Independent Sample T-test Results of Average Retention Scores

Group	N	Mean	SD	df	t-value	p-value	Decision
Computer Simulation	30	68.74	9.32	57	1.12	0.66	Accepted
Computer Animation	29	61.15	11.12				

Table 4 presents the independent sample t-test results for the average retention scores of students taught using computer simulation and animation methods in a flipped classroom setting. The analysis shows a t-value of 1.12 and a p-value of 0.66. Since the p-value is more significant than 0.05, the null hypothesis is accepted, indicating no significant difference in the average retention scores between the two groups. This finding suggests that both instructional methods are equally effective in promoting knowledge retention in a flipped classroom environment, giving educators the flexibility to choose either approach without compromising long-term learning outcomes.

Discussion

The findings of this study reveal that both computer simulation and animation instructional methods in a flipped classroom setting significantly enhance students' academic achievement. Despite the substantial increase in post-test scores relative to pre-test scores for both groups, the t-test results indicate no significant difference in educational attainment between the two groups. This outcome suggests that both instructional techniques are equally effective in boosting students' academic performance, allowing educators to choose either approach to achieve similar improvements in a flipped classroom setting. These findings align with previous research, which indicates that integrating technology into education can positively impact student learning outcomes (Joshi, 2023; Mandal & Srinivas, 2022; Wang, 2023). Additionally, studies have found that flipped classrooms significantly enhance student achievement, with consistent increases in student engagement and motivation (Faloye & Faniran, 2023; Malicay, 2023). This study confirms that technology can enrich the learning experience and help students achieve meaningful academic outcomes.

Furthermore, research indicates that incorporating videos in a flipped classroom setting can significantly improve student performance and retention compared to traditional teaching methods (Atwa et al., 2022; Palmero et al., 2023). It supports our findings that computer simulations and animations effectively enhance students' academic achievement (Hamamous et al., 2022). Additional research corroborates these results, demonstrating that using PowerPoint and animations in education can significantly boost student performance (Falode & Mohammed, 2023). This study underscores the importance of visualization and interactivity in improving students' understanding and retention of complex concepts (Fang & Guo, 2022).

Beyond academic achievement, the retention results show that both groups were able to retain the knowledge they acquired during the teaching period. However, no significant difference was found between the computer simulation and animation groups, indicating that both methods are equally effective. Similar results have been found in other research, where flipped classrooms have improved student knowledge retention through interactive and engaging digital materials (Masood et al., 2022). Additionally, research suggests that flipped classrooms can enhance students' critical and analytical thinking skills, essential for understanding and applying learned concepts (Cueva & Inga, 2022). These findings support the conclusion that both instructional methods effectively enhance student learning outcomes. Moreover, research indicates that incorporating technology in education can personalize learning and adapt to individual learning paces, thereby improving academic achievement and retention (Liu et al., 2023; Sotelo Gomez et al., 2022). Integrating technology into teaching gives students the flexibility and convenience necessary to learn more (Aidoo et al.,

2022; Falode & Mohammed, 2023; Fang & Guo, 2022).

Research confirms the importance of developing a technology-integrated curriculum and enhancing teachers' competencies using modern technological tools to improve student learning outcomes (Horbatiuk et al., 2023). These findings reinforce our research, demonstrating the positive impact of incorporating technology in a flipped classroom setting. Moreover, studies indicate that educational technology can alleviate the shortage of qualified teachers and address the limitations of conventional teaching methods (Petrova et al., 2023). It supports our conclusion that both instructional techniques can effectively enhance student learning outcomes, even when educational resources are limited (Singh, 2023). Additionally, research confirms that computer simulations can facilitate understanding complex concepts through interactive visualization, improving student performance and retention (Cant et al., 2022). These findings are consistent with our research results, showing that implementing digital simulations and animations in a flipped classroom setting effectively enhances students' academic achievement and retention (Beichumila et al., 2022; Hamamous et al., 2022).

Overall, the findings of this study reveal that educational technology in a flipped classroom setting successfully boosts students' academic achievement and retention. The similarity in effectiveness between digital simulations and animations indicates that both approaches can equally enhance learning outcomes. This flexibility allows educators to choose the method that best aligns with their instructional objectives and the unique needs of their students.

CONCLUSION

This study validates that computer simulation and animation instructional packages in a flipped classroom setting can effectively improve students' academic achievement and retention. Although there was no significant difference between the two groups, both demonstrated considerable progress in post-test scores compared to their pre-test results. These findings align with previous research, which shows that educational technology can enhance students' learning outcomes and engagement. Additionally, flipped classrooms have proven effective in improving learner engagement, motivation, and the development of critical reasoning and analytical abilities. The use of interactive digital materials also enhances students' knowledge retention. This study underscores the importance of developing technology-integrated curricula and improving teachers' competencies. Technology in education facilitates understanding complex concepts and personalizes learning according to students' pace, which is particularly important in resource-limited situations. This study advocates for incorporating technology in education to foster a more inclusive, engaging, and efficient learning environment, ultimately improving students' academic performance and knowledge retention.

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