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# Effects Of Computer Animation And Flipped Classroom Teaching Strategies On Students' Interest And Achievement In Thermal Energy In FCT, Abuja, Nigeria

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## ABSTRACT

This study investigated the Effects of Computer Animation and Flipped Classroom Teaching Strategies on Students' Interest, Achievement and Retention in Thermal Energy in FCT, Abuja, Nigeria. Quasi experimental research was used for this study. The population for this research comprised 9,989 public Upper Basic II students in F.C.T Abuja for 2023/2024 academic session. Simple random sampling technique was used to draw the sample of 170 (85 males and 85 females) students for the study. Two research questions guided the study and two research null hypotheses were tested at 0.05 level of significance. Two instruments namely; Thermal Energy Interest Rating Scale (THEIRS) and Thermal Energy Achievement Test (THEAT) were employed for data collection. The reliability coefficient obtained for THEAT is 0.79 using Kuder-Richardson 21 (KR-21) and Cronbach Alpha formula was used to determine the reliability coefficient of 0.81 for THEIRS. Descriptive statistics of mean and standard deviation were used to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses. Bonferroni Multiple Comparisons was used to determine the direction of the difference between the groups. The study revealed that both Computer Animation (CA) and Flipped Classroom (FC) teaching strategies significantly enhanced students' interest in learning thermal energy compared to the Conventional Teaching Method (CTM). However, there was no significant difference in interest between students taught using CA and FC, indicating that both methods are equally engaging. In terms of academic achievement, CA outperformed FC, but there was no significant difference between CA and CTM. On the other hand, FC significantly improved students' achievement compared to CTM, showing that active learning environments like FC are more effective than traditional methods for both engagement and academic success. Overall, the study highlights the value of using technology-enhanced and active learning strategies in Basic Science education. Based on the findings, it is recommended that educators incorporate computer animations into Basic Science lessons, particularly for complex and abstract topics like thermal energy. Visualizations can provide students with clearer representations of scientific concepts, aiding comprehension and retention.

**Keywords:** Computer Animation (CA), Flipped Classroom (FC), Conventional Teaching Method (CTM), Thermal Energy

## INTRODUCTION

The modern educational landscape has seen a paradigm shift from traditional lecture-based approaches to more interactive and technology-integrated strategies aimed at improving student engagement and achievement. Among these, the use of computer animation and the flipped classroom strategy have emerged as two innovative pedagogical approaches with the potential to enhance students' learning experiences, particularly in complex subjects like thermal energy. Thermal energy, a critical concept in physics and engineering, involves abstract and dynamic processes such as heat transfer, thermodynamics, and energy conservation. Teaching these concepts has posed challenges for educators due to their abstract nature, which often leads to low student interest and achievement. Therefore, innovative teaching strategies that can simplify these concepts and make learning more engaging are essential for improving student outcomes.

Computer animations have been widely recognized for their ability to visually represent complex and abstract scientific phenomena. Research indicates that animations can improve students' comprehension by providing dynamic, interactive visualizations that enhance conceptual understanding (Yilmaz & Öztürk, 2023). In the context of thermal energy, animations can effectively demonstrate processes such as conduction, convection, and radiation, which are difficult to visualize in traditional static diagrams. Studies show that computer animations not only improve students' academic achievement but also increase their interest in learning science by making the content more engaging and accessible (Lin, Wu, & Chang, 2022).

The flipped classroom teaching strategy inverts traditional teaching by delivering instructional content outside of class (often through videos or readings) and using class time for active learning activities, such as discussions, problem-solving, and experiments. This strategy shifts the focus from passive reception of knowledge to active participation, which has been shown to foster deeper understanding and retention of scientific concepts (Bishop & Verleger, 2021). In the teaching of thermal energy, the flipped classroom approach allows students to explore foundational concepts at their own pace before class and engage in hands-on, collaborative activities during class time. Recent studies suggest that this strategy enhances both student achievement and interest, as it promotes active engagement and facilitates personalized learning (He, Switzer & Everett, 2023).

### Statement of the Problem

The teaching and learning of thermal energy concepts, such as heat transfer, thermodynamics, and energy conservation, have long posed significant challenges in Basic Science. These concepts are inherently abstract, often requiring students to visualize molecular-level interactions and grasp complex scientific principles that are not easily demonstrated in traditional classroom settings. As a result, many students struggle to develop a deep understanding of thermal energy, leading to poor academic performance and low interest in the subject (Lin, Wu, & Chang, 2022). Traditional instructional methods, such as lectures and textbook-based learning, often fail to engage students adequately, especially when teaching difficult scientific content. These conventional approaches tend to focus on passive learning, where students play a more passive role in the acquisition of knowledge. Numerous studies have shown that such methods are less effective in promoting conceptual understanding and long-term retention, particularly in STEM (Science, Technology, Engineering, and Mathematics) education (Mayer, 2020). Consequently, many students exhibit disinterest and disengagement in thermal energy topics, which impacts both their short-term achievement and their likelihood of pursuing further studies in science-related fields.

In response to these challenges, innovative teaching strategies, such as computer animations and the flipped classroom strategy, have gained attention for their potential to enhance student learning outcomes. Computer animations offer dynamic visual representations of abstract scientific concepts, making them more tangible and comprehensible to learners. Through visual simulations, students can observe processes such as conduction, convection, and radiation in real time, allowing them to develop a clearer understanding of the interactions between particles and the flow of thermal energy (Yilmaz & Öztürk, 2023). Similarly, the flipped classroom approach promotes active learning by shifting the passive consumption of instructional content outside the classroom and using in-class time for problem-solving, collaborative activities, and deeper engagement with the material (Bishop & Verleger, 2021).

While both computer animations and flipped classroom strategies have been shown to improve student engagement and achievement individually, there is limited research on their effects, particularly in the context of thermal energy. This gap in the literature raises critical questions for educators and researchers alike: Can computer animations and flipped classroom strategies significantly improve student achievement and interest in thermal energy? How effective are these methods in addressing the inherent challenges of teaching abstract concepts, and what impact do they have on long-term retention and conceptual understanding? Without addressing these questions, educators may continue to rely on less effective teaching methods, potentially limiting student success in thermal energy and broader STEM fields. Thus, the problem that this study seeks to address is the lack of comprehensive evidence on the effects of computer animation and flipped classroom teaching strategies on students' interest and achievement in thermal energy. Given the importance of thermal energy concepts in various fields of science and engineering, it is critical to identify effective teaching approaches that can foster deeper understanding, sustained interest, and improved academic performance in this area. This research aims to fill this gap by investigating how these two innovative strategies, both individually and in combination, can enhance student outcomes in thermal energy.

## LITERATURE REVIEW

As education shifts towards more interactive and student-centered learning environments, technological advancements such as computer animations and pedagogical innovations like the flipped classroom have gained popularity. These strategies are designed to engage students more deeply in the learning process and improve their achievement, particularly in complex and abstract subjects like thermal energy. The combination of these two teaching approaches in Basic science education has the potential to enhance both student interest and academic achievement. The implementation of both computer animations and flipped classroom strategies in education is grounded in well-established learning theories. Cognitive Load Theory (CLT), proposed by Sweller (1988), provides a foundation for the use of multimedia tools like computer animations. CLT suggests that learners have limited working memory capacity, and using visual aids can help reduce cognitive load, allowing students to better process complex information. In thermal energy education, where abstract concepts such as heat transfer mechanisms are difficult to grasp, computer animations can simplify learning by providing visual representations (Mayer, 2020). Similarly, Constructivist Learning Theory supports the flipped classroom strategy by advocating for active learning. Vygotsky's (1978) ideas on social constructivism emphasize the importance of interaction and collaboration in learning. The flipped classroom shifts the instructional phase outside the classroom and creates opportunities for deeper exploration during class time, enabling students to construct their understanding through active engagement with peers and the instructor (Bishop & Verleger, 2021).

Numerous studies have examined the impact of computer animations on student achievement, particularly in science education. Computer animations provide dynamic and interactive representations of scientific phenomena that are often difficult to visualize using traditional static diagrams. This approach allows students to observe processes in real time, which can lead to improved conceptual understanding. For instance, Lin, Wu, and Chang (2022) found that the use of computer animations significantly enhanced students' understanding of thermodynamic concepts, leading to higher achievement scores. The study demonstrated that students who were exposed to animations showing molecular-level interactions during heat transfer outperformed those who received only textbook-based instruction. This aligns with Mayer's (2020) findings that multimedia learning tools help learners integrate visual and auditory information more effectively, leading to better retention and comprehension. In addition to improving achievement, computer animations have been shown to positively affect students' interest in science subjects. Yilmaz and Öztürk (2023) found that students displayed higher levels of engagement and enthusiasm when animations were incorporated into lessons on thermodynamics. The researchers argue that animations make learning more stimulating and enjoyable, which fosters greater interest. Given that interest is a key predictor of academic success, the use of computer animations is a promising tool for increasing both engagement and achievement in thermal energy.

The flipped classroom strategy has been widely studied in the context of science and mathematics education. This pedagogical strategy reverses the traditional sequence of teaching by assigning instructional content (videos, readings, or interactive tutorials) as homework and dedicating class time to hands-on activities, problem-solving, and discussion. The flipped classroom is particularly effective in promoting active learning, which is crucial for deep understanding of scientific concepts (He, Switzer, & Everett, 2023). Research shows that the flipped classroom strategy positively influences both academic achievement and student interest. In a meta-analysis, Clark et al. (2022) found that students who participated in flipped classrooms demonstrated better performance on assessments than those who were taught through traditional methods. The study attributed this to the fact that flipped classrooms allow students to engage more deeply with the material, providing them with more opportunities for critical thinking and application of knowledge during class time.

In the teaching of thermal energy, flipped classrooms offer unique benefits. By allowing students to review fundamental concepts (such as heat capacity, thermal equilibrium, and conduction) at their own pace outside of class, instructors can dedicate in-class time to hands-on experiments and collaborative problem-solving. This enhances students' understanding by providing opportunities for active learning. According to Herreid and Schiller (2019), the flipped classroom strategy promotes greater interaction and student engagement, making it particularly effective in Basic science education. While the benefits of computer animations and flipped classrooms are well-documented, there are some challenges associated with their implementation. One of the key issues is the technological divide, where students may not have access to the necessary devices or internet connectivity to engage with flipped classroom content outside of school (Bergmann & Sams, 2016). Similarly, the development of high-quality computer animations requires significant time and resources, which may pose a barrier for educators with limited technological expertise or funding. Moreover, some studies suggest that students who are not accustomed to self-directed learning may struggle with the flipped classroom strategy, particularly if they do not engage with the instructional materials prior to class (Chen et al., 2021). Therefore, the success of these strategies depends on careful planning and support from instructors to ensure that students are well-prepared to benefit from these approaches.

**Objective of the Study**

The main purpose of the study is to examine the effects of Computer Animation and Flipped Classroom Teaching Strategies on Students' Interest and Achievement in Thermal Energy in Abuja, Nigeria. The specific objectives of the study are to:

1. ascertain the effects of Computer Animation and Flipped Classroom Teaching Strategies on students' interest in thermal energy.
2. establish the effects of Computer Animation and Flipped Classroom Teaching Strategies on students' achievement in thermal energy.

**Research Questions**

The following research questions guided the study:

1. What is the interest rating of students taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach?
2. What is the achievement of students taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach?

**Statement of Hypotheses**

The following hypotheses were formulated and were tested at $\alpha$=0.05 level of significance.

**$H_{O1}$:** There is no significance difference in the mean interest ratings of students taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

**$H_{O2}$:** There is no significance difference in the mean achievement scores of student taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

The findings from this study will contribute to the growing body of knowledge on technology-enhanced and student-centered teaching approaches, helping to clarify the benefits and limitations of these strategies in STEM education. Understanding the relationship between teaching strategies and student outcomes is vital for improving student achievement and interest in complex subjects like thermal energy. By investigating how computer animations and flipped classrooms affect students' understanding and engagement, this study can help identify best practices for teaching abstract scientific concepts. The results could provide educators with effective tools to enhance students' comprehension of topics like heat transfer, thermodynamics, and energy conservation, leading to improved performance on assessments and a deeper conceptual understanding.

Additionally, the study addresses the issue of student interest, which is a key driver of academic success. Research has shown that students who are more interested in a subject tend to be more motivated and engaged in their learning, which correlates with better achievement outcomes (Clark et al., 2022). If this study finds that these teaching strategies can significantly boost interest in thermal energy, it may help spark a long-term interest in STEM fields, encouraging more students to pursue careers in science and engineering. This study is significant for educators and curriculum designers seeking more effective ways to teach difficult and abstract scientific concepts. Thermal energy concepts, including conduction, convection, and radiation, are often challenging for students to grasp through traditional teaching methods. The use of computer animations can visually represent these processes, making them more accessible to students, while the flipped classroom strategy promotes active engagement during class time, allowing for a more interactive learning experience.

Teachers play a critical role in the successful implementation of innovative teaching methods. This study provides valuable insights that could inform teacher professional development programs, particularly in the areas of technology integration and active learning strategies. By understanding how computer animations and flipped classrooms impact student learning, educators can develop their instructional skills and design more engaging and effective lessons. This will also empower teachers to move beyond traditional lecture-based approaches and embrace more interactive, student-centered teaching methods that are aligned with modern educational practices.

## METHODOLOGY

This study employed quasi-experimental pretest-posttest control group design. The quasi-experimental design is appropriate for this research because it allows for the comparison of groups that receive different teaching interventions (computer animation and flipped classroom) with a control group that uses traditional teaching methods. The study involved three groups:

1. Group A (Experimental Group 1): Students taught using computer animations in a traditional classroom setting.
2. Group B (Experimental Group 2): Students taught using the flipped classroom strategy with instructional content delivered outside class (pre-recorded videos and readings) and in-class time dedicated to problem-solving and interactive activities.
3. Group C (Control Group): Students taught using traditional lecture-based instruction without any technological interventions.

A pretest was administered to all groups before the intervention to assess their baseline knowledge and interest in thermal energy, followed by the teaching intervention, and then a posttest to measure changes in student achievement and interest. The population for this study comprised 9,989 public Upper Basic II students in Abuja for 2023/2024 academic session classes that cover thermal energy topics. A convenience sampling technique was used to select schools that have the necessary technological resources for implementing the interventions. The sample comprised 178 students (divided into three groups of 55 for computer animation group, 60 for flipped classroom group and 63 for the conventional group, representing the experimental and control groups. The sample was balanced by gender, academic background, and school location to minimize potential biases. Students' assent was obtained before participation. Two instruments were used for data collection; Thermal Energy Achievement Test (THEAT) on Thermal Energy consists of 30-multiple choice items adopted from Basic Education Certificate Examination (BECE, 2018-2022), based on thermal energy concepts such as; heat flow, method of heat transfer, conduction, convection, radiation and applications of methods of heat transfer was administered before and after the intervention. This test served as the pretest and posttest. Thermal Energy Interest Rating Scale (THEIRS) a 25-item instrument was designed to determine students' interest in Thermal energy. THEIRS was rated using a four-point scale. The options are; Strongly agreed (SA) = 4 points, Agree (A) = 3 points, Disagree (D) = 2 points and Strongly Disagreed (SD) = 1 point. Scoring this instrument -- this 4-point Likert type scale was scored on the basis of positive and negative response to each item. It was used to measure students' interest toward learning thermal energy. The items were open-ended questions that allow students to express their thoughts and experiences with the teaching methods. The instruments were validated by experts in Basic Science Education to ensure that they align with the curriculum and the concepts being taught. The reliability coefficient obtained for THEAT is 0.79 using Kuder-Richardson 21 (KR-21) and Cronbach Alpha formula was used to determine the reliability coefficient of 0.81 for THEIRS.

The research proceeded through the following steps:

Pretest Administration: All groups (A, B, and C) took the pretest to establish baseline knowledge and interest in thermal energy.

Intervention Phase:

i. Group A (Computer Animation): This group received traditional lectures supplemented with computer animations that visually demonstrate thermal energy processes, such as conduction, convection, and radiation. Animations was integrated into regular classroom lessons to help students visualize these abstract concepts.
ii. Group B (Flipped Classroom): This group was exposed to the flipped classroom strategy. Students received instructional materials (videos, readings, and animations) to study at home before class. In-class time was used for interactive discussions, group problem-solving, and experiments related to thermal energy.
iii. Group C (Control Group): The control group was taught using traditional lecture-based methods without animations or flipped classroom interventions.

Posttest Administration: After the intervention, a posttest identical to the pretest was administered to all groups to measure the change in students' knowledge of thermal energy. The interest questionnaire was administered after the intervention to assess changes in student interest and motivation. Data were analyzed using both descriptive and inferential statistics. Mean scores for the achievement tests and interest scores were calculated for each group (A, B, and C). The effectiveness of the interventions was evaluated using an Analysis of Covariance (ANCOVA), controlling for the pretest scores to compare the posttest performance between the groups. The ANCOVA determined whether there are statistically significant differences in achievement between the groups, particularly between the experimental groups (A and B) and the control group (C).

## RESULT OF FINDINGS

**Research Question One:** *What is the interest rating of students taught thermal energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using conventional teaching approach?*

Table 1: Mean Interest Rating and Standard Deviation of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| Group | | PreInterest | PostInterest |
|---|---|---|---|
| | Mean | 52.87 | 63.44 |
| CompAnimation | N | 55 | 55 |
| | Std. Deviation | 5.699 | 6.158 |
| | Mean | 52.65 | 64.28 |
| FlippedClass | N | 60 | 60 |
| | Std. Deviation | 5.105 | 6.455 |
| | Mean | 51.41 | 54.05 |
| Conventional | N | 63 | 63 |
| | Std. Deviation | 5.154 | 5.476 |

Table 1 reveals the mean interest ratings of students taught thermal energy using Computer Animation and Flipped Classroom Strategies and those taught using Conventional Method. The Computer Animation group had a pre-interest score of 52.87 with a standard deviation of 5.699 and a post-interest score of 63.44 with a standard deviation of 6.158, the Flipped Classroom group had a pre-interest score of 52.65 with a standard deviation of 5.105 and a post-interest score of 64.28 with a standard deviation of 6.455 and the Conventional group had a pre-interest score of 51.41 with a standard deviation of 5.154 and a post-interest of 54.05 with a standard deviation of 5.476.

**Hypothesis One**

$H_{O1}$: There is no significance difference in the mean interest ratings of students taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

Table 2: ANCOVA Result on Interest of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Strategy | 4117.663[a] | 3 | 1372.554 | 38.514 | .000 | .399 |
| Intercept | 4659.886 | 1 | 4659.886 | 130.756 | .000 | .429 |
| PreInterest | 163.551 | 1 | 163.551 | 4.589 | .034 | .026 |
| Group | 3709.218 | 2 | 1854.609 | 52.040 | .000 | .374 |
| Error | 6201.017 | 174 | 35.638 | | | |
| Total | 659667.000 | 178 | | | | |
| Corrected Total | 10318.680 | 177 | | | | |

a. R Squared = .399 (Adjusted R Squared = .389)

Table 2 reveals $F_{(2,174)}$ = ratio of 52.040 was obtained with associated exact probability value of 0.000 ($F_{(2,174)} = 52.040$; $p = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there is a significant difference in the mean interest ratings of students taught thermal energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 3.

Table 3: Bonferroni Multiple Comparisons Result on Interest of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| CompAnimation | FlippedClass | -.887 | 1.115 | 1.000 | -3.582 | 1.807 |
| | Conventional | 9.123* | 1.109 | .000 | 6.443 | 11.803 |
| FlippedClass | CompAnimation | .887 | 1.115 | 1.000 | -1.807 | 3.582 |
| | Conventional | 10.011* | 1.082 | .000 | 7.395 | 12.626 |
| Conventional | CompAnimation | -9.123* | 1.109 | .000 | -11.803 | -6.443 |
| | FlippedClass | -10.011* | 1.082 | .000 | -12.626 | -7.395 |

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 3 shows that there was a significant difference in the mean interest rating scores of students taught thermal energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using conventional teaching approach. Computer Animation and Flipped Classroom had a p value of $1.000 > \alpha = 0.05$, since 1.000 is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean scores of students exposed to Computer Animation and Flipped Classroom. Computer Animation and Conventional had a p value of $0.000 < \alpha = 0.05$, since 0.000 is greater than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean scores of students exposed to Computer Animation and Conventional method in the favour of the Computer Animation. Flipped Classroom and Conventional approach had a p value of $0.000 < \alpha = 0.05$, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean ratings of students exposed to Flipped Classroom and Conventional approach in favour of the Flipped Classroom strategy.

**Research Question Two***: What is the achievement of students taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach?*

Table 4: Mean Achievement and Standard Deviation of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| Group | | Pretest | Posttest |
|---|---|---|---|
| CompAnimation | Mean | 21.98 | 28.98 |
| | N | 55 | 55 |
| | Std. Deviation | 4.361 | 5.159 |
| FlippedClass | Mean | 22.97 | 32.00 |
| | N | 60 | 60 |
| | Std. Deviation | 5.330 | 3.813 |
| Conventional | Mean | 17.67 | 26.62 |
| | N | 63 | 63 |
| | Std. Deviation | 3.737 | 3.113 |

Table 4 reveals the mean achievement scores of students taught thermal energy using Computer Animation and Flipped Classroom Strategies and those taught using Conventional Method. The Computer Animation group had a pre-test score of 21.98 with a standard deviation of 4.361 and a post-test score of 28.98 with a standard deviation of 5.159, the Flipped Classroom group had a pre-test score of 22.97 with a standard deviation of 5.330 and a post-test score of 32.00 with a standard deviation of 3.813 and the Conventional group had a pre-test score of 17.67 with a standard deviation of 3.737 and a post-test of 26.62 with a standard deviation of 3.113.

**Hypothesis Two**

$H_{O2}$: There is no significance difference in the mean achievement scores of student taught thermal energy using Computer Animation, Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

Table 5: ANCOVA Result on Achievement of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Strategy | 1946.967[a] | 3 | 648.989 | 61.328 | .000 | .514 |
| Intercept | 2496.501 | 1 | 2496.501 | 235.914 | .000 | .576 |
| Pretest | 1054.530 | 1 | 1054.530 | 99.651 | .000 | .364 |
| Group | 223.327 | 2 | 111.664 | 10.552 | .000 | .108 |
| Error | 1841.309 | 174 | 10.582 | | | |
| Total | 155173.000 | 178 | | | | |
| Corrected Total | 3788.275 | 177 | | | | |

a. R Squared = .514 (Adjusted R Squared = .506)

Table 5 reveals $F_{(2,174)}$ = ratio of 10.552 was obtained with associated exact probability value of 0.000 ($F_{(2,174)} = 10.552$; $p = 0.000 < \alpha = 0.05$). Since the associated probability (0.000) is less than 0.05 set as level of significance, the null hypothesis was rejected. This indicates that there is a significant difference in the mean achievement of students taught thermal energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using conventional teaching approach.

Based on the established difference in the achievement scores of the groups, Bonferroni Multiple Comparisons was used to determine the direction of the difference. The results of this analysis is shown in Table 6.

Table 6: Bonferroni Multiple Comparisons Result on Interest of Students taught Thermal Energy using Computer Animation and Flipped Classroom Teaching Strategies and those taught using Conventional Teaching Approach

| (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig.[b] | 95% Confidence Interval for Difference[b] | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| CompAnimation | FlippedClass | -2.483* | .610 | .000 | -3.957 | -1.009 |
| | Conventional | .017 | .645 | 1.000 | -1.541 | 1.576 |
| FlippedClass | CompAnimation | 2.483* | .610 | .000 | 1.009 | 3.957 |
| | Conventional | 2.500* | .654 | .001 | .919 | 4.081 |
| Conventional | CompAnimation | -.017 | .645 | 1.000 | -1.576 | 1.541 |
| | FlippedClass | -2.500* | .654 | .001 | -4.081 | -.919 |

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Table 6 shows that Computer Animation and Flipped Classroom had a p value of $0.000 < \alpha = 0.05$, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean achievement of students exposed to Computer Animation and Flipped Classroom. Computer Animation and Conventional had a p value of $1.000 > \alpha = 0.05$, since 0.000

is greater than 0.05 set as bench mark of significance, the hypothesis was not rejected which implies no significant difference between the mean scores of students exposed to Computer Animation and Conventional approach. Flipped Classroom and Conventional approach had a p value of 0.001 < α = 0.05, since 0.000 is less than 0.05 set as bench mark of significance, the hypothesis was rejected which implies a significant difference between the mean ratings of students exposed to Flipped Classroom and Conventional approach in favour of the Flipped Classroom strategy.

## DISCUSSION OF FINDINGS

The study examines the effects of Computer Animation (CA) and Flipped Classroom (FC) teaching strategies on students' interest and achievement in thermal energy, compared to the Conventional Teaching Method (CTM). The findings, analyzed through p-values, suggest significant differences in both interest and achievement across the instructional strategies. This section provides a critical analysis of the findings in relation to existing literature.

### Interest Findings

The study revealed a significant difference in students' interest when taught using CA and FC compared to CTM. However, no significant difference in interest was found between CA and FC, as indicated by a p-value of 1.000.

a. Computer Animation vs. Flipped Classroom (Interest)

The p-value of 1.000 (p > 0.05) indicates that students exposed to CA and FC did not differ significantly in their levels of interest. Both methods proved equally effective in engaging students, reflecting findings from previous research that highlights the importance of active learning environments. Clark and Mayer (2016) suggest that interactive learning methods, such as animations and flipped classrooms, can stimulate cognitive engagement, leading to heightened student interest. However, neither approach demonstrated a statistically significant advantage over the other in this study, indicating that both methods foster comparable levels of interest.

The equivalence in interest between CA and FC may stem from their shared characteristic of student-centered learning. In CA, students are presented with visual representations of complex thermal energy processes, which make abstract concepts more concrete (Mayer, 2021). Meanwhile, FC shifts the learning dynamic by allowing students to engage with materials at their own pace before coming to class, thus fostering autonomy and ownership of their learning (Bishop & Verleger, 2013). Both methods promote active involvement, which is closely associated with increased motivation and interest in science subjects (Pintrich, 2003).

b. Computer Animation vs. Conventional Teaching (Interest)

The p-value of 0.000 (p < 0.05) suggests a significant difference in favor of CA over CTM in terms of student interest. This finding is consistent with literature that emphasizes the benefits of technology-enhanced learning in capturing students' attention and increasing their engagement with the material. According to Smetana and Bell (2012), computer animations can simplify complex scientific concepts, making them more accessible and engaging to learners. Visualizations provide dynamic representations of scientific phenomena that are often difficult to understand through static images or verbal explanations alone (Rapp & Kurby, 2008). In thermal energy education, for instance, animations can illustrate heat transfer processes (e.g., conduction and radiation) in real-time, allowing students to visualize concepts that are otherwise abstract in nature (de Jong et al., 2021).

The significant increase in interest with CA aligns with multimedia learning theory, which posits that the integration of visual and auditory information enhances student engagement and comprehension (Mayer, 2021). The immersive nature of animations provides students with interactive, sensory-rich experiences that can enhance their interest in learning (Clark & Mayer, 2016). In contrast, CTM, which typically relies on lectures and textbooks, may fail to stimulate students as effectively, leading to lower engagement levels.

c. Flipped Classroom vs. Conventional Teaching (Interest)

Similarly, the p-value of 0.000 ($p < 0.05$) indicates a significant difference in interest in favor of FC over CTM. This aligns with research by Bergmann and Sams (2012), which found that flipped classrooms promote higher levels of student engagement by offering more opportunities for active learning and peer interaction. In the flipped strategy, students are responsible for their initial learning outside the classroom, and class time is dedicated to applying knowledge through discussions, problem-solving, and hands-on activities. This shift from passive to active learning has been shown to increase student interest, as it encourages collaboration, critical thinking, and deeper engagement with the material (Bishop & Verleger, 2013).

Moreover, Abeysekera and Dawson (2015) argue that flipped classrooms cater to different learning styles, allowing students to engage with content at their own pace, which can increase both motivation and interest. The flexibility provided by FC gives students more control over their learning, potentially leading to greater satisfaction and engagement. In contrast, CTM's one-size-fits-all approach may not accommodate diverse learning preferences, contributing to lower interest levels.

**Achievement Findings**

For student achievement, the analysis revealed significant differences between the groups, with varied results for CA, FC and CTM.

a. Computer Animation vs. Flipped Classroom (Achievement)

The p-value of 0.000 ($p < 0.05$) indicates a significant difference in favor of CA over FC in terms of student achievement. This finding suggests that while CA and FC are equally effective in increasing interest, CA may have a more pronounced effect on students' academic performance in thermal energy. This aligns with Mayer's (2021) cognitive theory of multimedia learning, which posits that students learn more effectively when information is presented through both visual and verbal channels. In the case of thermal energy, the dynamic, visual nature of CA may help students develop a deeper understanding of heat transfer processes by allowing them to observe these phenomena in action.

Research by de Jong et al. (2021) supports this finding, demonstrating that animations can enhance student achievement by promoting conceptual understanding and reducing cognitive load. The real-time visualizations provided by CA likely enable students to better grasp abstract concepts, such as the behavior of particles during heat transfer. In contrast, FC, while fostering critical thinking and collaboration, may not provide the same level of direct conceptual clarity, especially for students who struggle with the self-directed nature of pre-class learning materials (Bishop & Verleger, 2013).

b. Computer Animation vs. Conventional Teaching (Achievement)

Interestingly, the p-value of 1.000 ($p > 0.05$) indicates no significant difference in achievement between CA and CTM. This suggests that while CA may enhance interest, it does not necessarily lead to higher achievement compared to traditional methods. This finding contradicts some research that highlights the effectiveness of animations in improving student understanding (Mayer, 2021). However, it is possible that factors such as student familiarity with technology or the quality of the animations used in the study affected the results. Clark and Mayer (2016) caution that the mere use of animations does not guarantee improved learning outcomes; the design and implementation of the technology must be pedagogically sound. Moreover, Schroeder et al. (2011) argue that traditional methods, particularly when delivered by experienced teachers, can still be effective in conveying core scientific concepts. In this case, CTM may have provided students with sufficient content knowledge to perform well on assessments, despite being less engaging.

c. Flipped Classroom vs. Conventional Teaching (Achievement)

The p-value of 0.001 ($p < 0.05$) indicates a significant difference in favor of FC over CTM for student achievement. This finding is consistent with previous research showing that FC can improve academic performance by shifting the focus of class time from content delivery to active learning (Bishop & Verleger, 2013). In FC, students are able to engage more deeply with the material through peer collaboration and instructor feedback during class, which can lead to better retention and understanding of concepts (Abeysekera & Dawson, 2015). The FC strategy's success in improving achievement may also be attributed to its scaffolded learning approach, which allows students to build on their pre-class knowledge during in-class activities (Bergmann & Sams, 2012). In contrast, CTM's lecture-based approach may not provide the same level of individualized feedback and active engagement, potentially limiting students' ability to apply what they have learned in meaningful ways.

**Implications for Basic Science Teaching**

The findings from this study underscore the importance of active, technology-enhanced learning environments in increasing both student interest and achievement in Basic science education. While CA and FC have distinct strengths, both methods appear to be more effective than CTM in fostering engagement and improving learning outcomes. The results suggest that integrating multimedia and active learning strategies into Basic science curricula can benefit students, particularly when teaching complex and abstract concepts like thermal energy. However, it is also clear that no single teaching method is universally superior. Both CA and FC have advantages and limitations, and their effectiveness may depend on factors such as student learning preferences, instructional design, and the nature of the content being taught. Future research should explore how these strategies can be combined or tailored to meet the diverse needs of students.

## CONCLUSION

The findings demonstrated that both CA and FC significantly increased students' interest in learning thermal energy concepts compared to CTM. However, no significant difference was found in interest between students taught using CA and those taught using FC. This suggests that both methods are equally effective in engaging students, offering dynamic and interactive learning environments that cater to students' active participation and cognitive engagement. In terms of achievement, significant differences were found between the teaching methods. CA was more effective than FC in improving student achievement, reflecting the importance of visual aids in enhancing comprehension of complex concepts like thermal energy. However, no significant difference in achievement was observed between CA and CTM, suggesting that the effectiveness of CA may depend on various factors, including its integration into the curriculum and students' familiarity with the technology. FC, on the other hand, significantly outperformed CTM in both interest and achievement, highlighting the value of active learning environments in promoting deeper understanding and better academic performance.

Overall, the findings suggest that technology-enhanced learning and active learning strategys hold significant potential for improving both student engagement and academic success in science education, particularly in subjects like thermal energy, where abstract concepts can be difficult to grasp through traditional teaching methods.

## RECOMMENDATIONS

Based on the findings, the following recommendations are proposed:

1. Integrate Technology-Enhanced Learning (CA) into Science Curricula: Given the significant improvement in student interest and achievement through CA, it is recommended that educators incorporate computer animations into science lessons, particularly for complex and abstract topics like thermal energy. Visualizations can provide students with clearer representations of scientific concepts, aiding comprehension and retention.
2. Adopt Flipped Classroom (FC) Strategies for Active Learning: FC's effectiveness in improving both interest and achievement suggests that this approach should be widely adopted in science education. Teachers can use pre-class video lectures or reading materials to shift the focus of in-class time to discussions, problem-solving, and collaborative learning. This strategy allows for deeper exploration of concepts and provides students with opportunities to apply their knowledge in meaningful ways.
3. Combine CA and FC for Optimal Learning Outcomes: The findings suggest that while CA improves engagement, FC fosters better achievement through active learning. Educators may consider combining CA and FC approaches, where animations are used in pre-class materials,

and classroom time is dedicated to applying concepts through interactive activities. This blended approach could leverage the strengths of both strategies to enhance student outcomes.

4. Provide Teacher Training and Support: To maximize the effectiveness of CA and FC, teachers need adequate professional development on how to integrate these strategies into their lessons. Training should focus on the pedagogical use of technology, ensuring that animations are used effectively to complement instruction, and on how to structure flipped classrooms to engage students meaningfully.
5. Address Technological Barriers and Access: Schools should ensure that students have access to the necessary technological infrastructure to benefit from CA and FC approaches. This includes access to devices, reliable internet, and digital resources. Furthermore, educators should be provided with support to troubleshoot technical challenges that may arise when implementing these methods.

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