

# Enhancing STEM Learning through the Activated Classroom Teaching Pedagogy: A Case Study in Primary Mathematics



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## ABSTRACT

Students often exhibit a strong aversion to STEM subjects, particularly Mathematics, leading to poor performance. This study thus explored the use of the Activated Classroom Teaching (ACT) pedagogy in addressing this aversion. The ACT model incorporates five core components: curation, conversation, correction, creation, and chaos—that promote active learning through technology. A seven-week intervention was conducted with 91 primary school students in Nigeria to evaluate the model's effect on student engagement and academic performance. Data was collected through pre- and post-intervention tests. Results indicated a significant improvement in students' performance, with an 8.79% increase in mean scores. This study highlights the potential of active digital pedagogies to transform mathematics education and improve outcomes in STEM subjects. The results of this study show that active learning strategies, especially those that leverage technology, can play a critical role in addressing the challenges associated with traditional mathematics education.

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### Publication History

Received:  
29<sup>th</sup> September, 2024  
Accepted:  
4<sup>th</sup> December, 2024  
Published online:  
24<sup>th</sup> December, 2024

**Keywords:** *Active Pedagogy, Activated Classroom Teaching, Mathematics Education, Technology Integration.*

## INTRODUCTION

Mathematics has historically been a challenging subject for many students, and this difficulty often leads to widespread anxiety and underachievement in the subject. This challenge is particularly prevalent in STEM (Science, Technology, Engineering, and Mathematics) fields, where mathematics forms the foundation for many critical concepts and applications. The issue of poor performance in Mathematics is pervasive, with many students expressing deep-seated fears or phobias that hinder their ability to grasp mathematical concepts.<sup>1</sup> One major contributing factor to this problem is the traditional pedagogy employed in teaching mathematics, which often fails to engage students actively, leaving them passive recipients of content.<sup>2</sup>

Over the years, there has been a growing awareness of the limitations of traditional teaching methods, especially in subjects such as Mathematics, where students need to engage with abstract concepts. Research has shown that passive learning approaches, where teachers dominate classroom

<sup>1</sup> Rajendra Kunwar, "Mathematics Phobia: Causes, Symptoms and Ways to Overcome," *International Journal of Creative Research Thoughts* 8, no. 8 (2020): 818–22.

<sup>2</sup> T. Sherrington, "How Do I Engage Passive Learners?," 2023, <https://teacherhead.com/2023/01/17/tps6-how-do-i-engage-passive-learners/>.

interactions, lead to disengagement and poor learning outcomes.<sup>3</sup> In response to these challenges, there has been a significant shift towards active learning pedagogies that prioritize student engagement and participation.<sup>4</sup>

In recent times, the integration of technology into teaching has also emerged as a potential solution to these issues. However, despite the technological advancements in education, many approaches have been passive in their application, offering little improvement in student performance.<sup>5</sup> For example, tools such as PowerPoint or video presentations, though widely used, often fail to engage students meaningfully, leading to what has been termed "death by PowerPoint".<sup>6</sup> This disconnect between the use of technology and its pedagogical application has prompted the search for more effective teaching models that leverage technology to engage students actively.

The Activated Classroom Teaching (ACT) pedagogy was developed to address these gaps. The ACT model is a digital-age teaching approach that combines active learning strategies with technology to foster deeper student engagement. It moves beyond traditional consumption-based learning by integrating five key pedagogical layers: curation, conversation, correction, creation, and chaos.<sup>7</sup> This approach aims to shift the focus from teacher-centered instruction to a student-centered learning process where learners actively participate in their own educational journey.

This paper, therefore, aims to investigate the impact of the ACT pedagogy on primary school students' performance in Mathematics. Specifically, it explores how this active, technology-enabled approach can enhance students' understanding and engagement in Mathematics. The central research question guiding this study is: How do students perform in Mathematics using the activated learning approach?

## LITERATURE REVIEW

### Traditional Teaching and Learning Approaches

Traditional teaching approaches have long been criticized for their failure to actively engage students, especially in subjects that require critical thinking and problem-solving, such as Mathematics. In traditional settings, teachers typically serve as the sole source of knowledge, delivering content in a one-way fashion, while students passively absorb information.<sup>8</sup> This model of instruction, often referred to as the "sage on the stage" approach, limits student interaction and discourages independent thought.<sup>9</sup> Research has shown that such passive learning environments can lead to poor retention of knowledge and limited conceptual understanding.<sup>10</sup>

In contrast, active learning approaches promote a more dynamic classroom environment where students are encouraged to engage with content through discussion, collaboration, and hands-on activities.<sup>11</sup> By engaging students in the learning process, active pedagogies facilitate the development of

<sup>3</sup> Sherrington, "How Do I Engage Passive Learners?"; Alias Masek and Sulaiman Yamin, "A Comparative Study of the Effect of Problem Based Learning and Traditional Learning Approaches on Students' Knowledge Acquisition," *International Journal of Engineering Education* 28, no. 5 (2012): 1161.

<sup>4</sup> Khe Foon Hew et al., "Transitioning to the 'New Normal' of Learning in Unpredictable Times: Pedagogical Practices and Learning Performance in Fully Online Flipped Classrooms," *International Journal of Educational Technology in Higher Education* 17 (2020): 1–22; Paul Bazelaïs and Tenzin Doleck, "Blended Learning and Traditional Learning: A Comparative Study of College Mechanics Courses," *Education and Information Technologies* 23, no. 6 (2018): 2889–2900; Scott Freeman et al., "Active Learning Increases Student Performance in Science, Engineering, and Mathematics," *Proceedings of the National Academy of Sciences* 111, no. 23 (2014): 8410–15.

<sup>5</sup> Craig Blewett, "From Traditional Pedagogy to Digital Pedagogy: Paradoxes, Affordances, and Approaches," in *Disrupting Higher Education Curriculum* (Brill, 2016), 265–87.

<sup>6</sup> Angela R Garber, "Death by Powerpoint," *Small Business Computing. Com*, 2001.

<sup>7</sup> C. Blewett, "Activated Classroom Teaching: A Pedagogy for the Digital Age," 2016.

<sup>8</sup> D. Adeboye, "Basic Learning Anatomy," 2016, <https://www.linkedin.com/pulse/basic-learning-anatomy-daniel-adeboye/>; Steve Olusegun Bada and Steve Olusegun, "Constructivism Learning Theory: A Paradigm for Teaching and Learning," *Journal of Research & Method in Education* 5, no. 6 (2015): 66–70.

<sup>9</sup> Masek and Yamin, "A Comparative Study of the Effect of Problem Based Learning and Traditional Learning Approaches on Students' Knowledge Acquisition."

<sup>10</sup> Roxana Ardeleanu, "Traditional and Modern Teaching Methods in Mathematics," *Journal of Innovation in Psychology, Education and Didactics* 23, no. 2 (2019): 133–40.

<sup>11</sup> Jennifer L Faust and Donald R Paulson, "Active Learning in the College Classroom," *Journal on Excellence in College Teaching* 9, no. 2 (1998).

critical thinking, creativity, and problem-solving skills—abilities that are particularly crucial for success in Mathematics.<sup>12</sup>

### Passive Use of Technology in Education

While technology has the potential to revolutionize education, its passive application in the classroom often fails to achieve the desired outcomes. Several studies have pointed out the limitations of using technology tools, such as PowerPoint or pre-recorded videos, in a manner that does not actively involve students in the learning process. Draper, Cargill, and Cutts found that students frequently become disinterested during lectures where technology is used merely as a presentational aid rather than as a tool for engagement.<sup>13</sup> Similarly, the phenomenon known as "death by PowerPoint" occurs when students are subjected to lengthy, text-heavy presentations that do little to stimulate learning.<sup>14</sup>

In Mathematics, where abstract concepts often require a more hands-on, interactive approach, passive technologies can exacerbate students' disengagement. Studies have shown that simply watching videos or viewing slideshows without active involvement can increase student anxiety and reduce their ability to grasp complex mathematical concepts.<sup>15</sup> Therefore, there is a growing consensus that technology must be paired with active learning strategies to be truly effective in improving student outcomes.<sup>16</sup>

### Active Learning Approaches in STEM Education

Active learning approaches have gained traction in recent years as effective alternatives to traditional, passive methods of instruction. In STEM education, active learning strategies have been shown to improve student engagement and performance significantly.<sup>17</sup> These approaches shift the focus from teacher-led instruction to student-centered activities that promote interaction, collaboration, and problem-solving. Active learning environments encourage students to engage with mathematical concepts through discussions, hands-on exercises, and collaborative projects, all of which contribute to a deeper understanding of the material.<sup>18</sup>

## METHODOLOGY

### Study Design

This study employed a Design-Based Research (DBR) approach to evaluate the effectiveness of the ACT pedagogy in enhancing student performance in Mathematics. DBR is an iterative process that involves planning, experimentation, and analysis to develop and refine educational interventions.<sup>19</sup> The intervention took place over a seven-week period, during which the ACT model's five layers—curation, conversation, correction, creation, and chaos—were applied in a Mathematics classroom setting.

### Participants

The study sample comprised 91 students from grades five and six in a primary school in Nigeria. The participants were selected using a purposive sampling technique, which ensured that students with varying levels of mathematical proficiency were included. This diverse sample allowed for a more comprehensive analysis of the ACT pedagogy's impact on different student groups.

### Intervention Procedure

The intervention was structured as follows:

<sup>12</sup> Juan D Aguilar-Peña et al., "Content Curation in E-Learning: A Case of Study with Spanish Engineering Students," *Applied Sciences* 12, no. 6 (2022): 3188; Freeman et al., "Active Learning Increases Student Performance in Science, Engineering, and Mathematics."

<sup>13</sup> Stephen W Draper, Julie Cargill, and Quintin Cutts, "Electronically Enhanced Classroom Interaction," *Australasian Journal of Educational Technology* 18, no. 1 (2002).

<sup>14</sup> Garber, "Death by Powerpoint."

<sup>15</sup> Ayesha Anwar et al., "Role of Mass Media and Public Health Communications in the COVID-19 Pandemic," *Cureus* 12, no. 9 (2020).

<sup>16</sup> Joan M Raines and Linda M Clark, "A Brief Overview on Using Technology to Engage Students in Mathematics," *Current Issues in Education* 14, no. 2 (2011).

<sup>17</sup> Freeman et al., "Active Learning Increases Student Performance in Science, Engineering, and Mathematics."

<sup>18</sup> Raines and Clark, "A Brief Overview on Using Technology to Engage Students in Mathematics."

<sup>19</sup> Koeno Gravemeijer and Paul Cobb, "Design Research from a Learning Design Perspective," in *Educational Design Research* (Routledge, 2006), 29–63.

**Week 1:** Introduction to the ACT pedagogy, focusing on the consumption layer. Students were introduced to basic mathematical concepts through traditional methods to establish a baseline.

**Week 2:** Application of the curation layer. Students were tasked with finding, gathering, and organizing content related to a specific mathematical topic. They were encouraged to use multiple resources, including textbooks and online videos, to enhance their understanding. Curation is also well supported by Aguilar-Peña et al. and Verhaart.<sup>20</sup>

**Week 3:** The focus shifted to the conversation layer, where students engaged in group discussions to solve mathematical problems. Peer tutoring and collaborative problem-solving were encouraged to foster deeper understanding. This concept of Conversation is in line with the study by Brown and Kennedy.<sup>21</sup>

**Week 4:** Introduction of the correction layer. Students were asked to identify and correct mistakes in sample problems, allowing them to learn from errors and improve their problem-solving skills. Correction was also supported by Fischer et al.<sup>22</sup>

**Week 5:** The creation layer was applied, where students were tasked with creating explainer videos to demonstrate their understanding of specific mathematical concepts. The concept of Creation is aligned and supported by the work of Majekodunmi and Murnaghan.<sup>23</sup>

**Week 6:** The final layer, chaos, was introduced. Students were presented with complex problems with missing variables, requiring them to apply previous knowledge and collaborate with peers to find solutions. The concept of Chaos was also well aligned to the study by Somerville and Green.<sup>24</sup>

**Week 7:** The intervention concluded with a review and a final test to assess student performance.

### Data Collection and Analysis

Data was collected through pre- and post-intervention tests designed to measure students' mathematical performance. These tests included a mix of problem-solving questions and conceptual understanding assessments. Additionally, qualitative data were gathered through classroom observations and student feedback to gauge their engagement with the ACT model.

Hence, a mixed-method approach was used to obtain the data. A focus group discussion (FGD) was carried out with four teachers. Quantitative analysis was carried out using SPSS. Descriptive statistics was performed, and qualitative analysis was performed as the FGD was transcribed and coded, and major themes were derived to support the quantitative analysis discussed.

### Ethical Considerations

All ethical procedures were followed, which included obtaining approval from the university's ethics committee. Furthermore, gatekeepers' permission was obtained from the management of the primary school, whose students and teachers were participants in the research. Finally, the participants were also informed that participation was voluntary and that they had the right to withdraw at any time from the study.

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<sup>20</sup> Aguilar-Peña et al., "Content Curation in E-Learning: A Case of Study with Spanish Engineering Students"; Michael Verhaart, "Curating Digital Content in Teaching and Learning Using Wiki Technology," in *2012 IEEE 12th International Conference on Advanced Learning Technologies* (IEEE, 2012), 191–93.

<sup>21</sup> Kirsty Brown and Hilary Kennedy, "Learning through Conversation: Exploring and Extending Teacher and Children's Involvement in Classroom Talk," *School Psychology International* 32, no. 4 (2011): 377–96.

<sup>22</sup> Melissa A Fischer et al., "Learning from Mistakes: Factors That Influence How Students and Residents Learn from Medical Errors," *Journal of General Internal Medicine* 21 (2006): 419–23.

<sup>23</sup> Norda Majekodunmi and Kent Murnaghan, "In Our Own Words': Creating Videos as Teaching and Learning Tools," *Partnership: The Canadian Journal of Library and Information Practice and Research* 7, no. 2 (2012).

<sup>24</sup> Margaret Somerville and Monica Green, "A Pedagogy of 'Organized Chaos': Ecological Learning in Primary Schools," *Children, Youth and Environments* 21, no. 1 (2011): 14–34.

## PRESENTATION OF RESULTS/FINDINGS

The analysis of student's academic performance before and after the intervention is presented in Table 1. The findings show a marked improvement in students' mathematical performance after introducing the Activated Classroom Teaching (ACT) pedagogy.

**Table 1. Academic Performance of Students in Mathematics**

Marks Range	Pre-Intervention (%)	Post-Intervention (%)
0-39	23.9% (22 students)	12.0% (11 students)
40-49	15.2% (14 students)	12.0% (11 students)
50-59	29.3% (27 students)	21.7% (20 students)
60-69	16.3% (15 students)	17.4% (16 students)
70 and above	15.2% (14 students)	37.0% (34 students)

### Summary of Results

**Performance Increase:** Prior to the intervention, only 31.5% of the students scored 60 and above. After the intervention, this number rose to 54.4%, demonstrating a significant improvement in students' performance after being taught with the ACT model.

**Reduction in Failure Rate:** The percentage of students scoring between 0-39 (failing range) dropped from 23.9% before the intervention to 12.0% after the intervention, indicating that fewer students failed Mathematics after introducing the ACT pedagogy.

**Mean Score Improvement:** There was a mean score increase of 8.79% post-intervention, moving from a pre-intervention mean of 56.15% to a post-intervention mean of 64.94%. This statistically significant improvement highlights the positive impact of active, technology-enabled learning on students' mathematical performance.

Qualitative analysis of the transcribed interviews of the teachers' FGD yielded three themes: engaging teaching methods, benefits of active learning, and improved learning outcomes. These themes emerged during and after the intervention.

The results confirm that the ACT pedagogy effectively improved students' performance in Mathematics, supporting the idea that active learning strategies, specifically those that integrate technology, can lead to better learning outcomes in STEM subjects.

## DISCUSSION

### Impact of the ACT Pedagogy on Student Performance

The results of this study align with existing research on the effectiveness of active learning pedagogies in improving student engagement and performance in Mathematics.<sup>25</sup> The ACT model's focus on student-centered learning, collaboration, and the use of digital tools encouraged students to take an active role in their learning process, thereby enhancing their understanding of mathematical concepts.

One of the key strengths of the ACT pedagogy is its ability to engage students through multiple modes of learning. By incorporating elements such as curation, conversation, correction, and creation, the ACT model allows students to approach problems from different perspectives, making abstract concepts more accessible. This active participation not only improves students' conceptual understanding but also helps them develop essential 21st-century skills such as problem-solving, critical thinking, and collaboration.<sup>26</sup>

The observed reduction in failure rates and the increase in high-achieving students (those scoring 70% or above) demonstrate that the ACT model effectively addresses the challenges associated with

<sup>25</sup> Freeman et al., "Active Learning Increases Student Performance in Science, Engineering, and Mathematics."

<sup>26</sup> Brown and Kennedy, "Learning through Conversation: Exploring and Extending Teacher and Children's Involvement in Classroom Talk"; Jesús Ribosa and David Duran, "Students Creating Videos for Learning by Teaching from Their Scientific Curiosity," *Research in Science & Technological Education* 42, no. 2 (2024): 237-54.

traditional teaching methods in Mathematics. In particular, the findings suggest that the shift from passive consumption to active content production has a profound impact on students' learning outcomes.

### **Active vs. Passive Learning with Technology**

The results of this study also highlight the limitations of passive technology use in the classroom. Before the intervention, many students experienced difficulty in understanding mathematical concepts, even when technology was incorporated into teaching, such as PowerPoint presentations or video explanations. These findings are consistent with previous research, which has shown that the passive use of technology in education often leads to disengagement and poor learning outcomes.<sup>27</sup>

In contrast, the ACT pedagogy's active approach to technology integration transformed the students' experience with digital tools. By engaging students in activities that required them to curate content, hold discussions, correct errors, and create their own learning materials, the ACT model ensured that technology was used as a means of engagement rather than mere presentation. This shift from passive to active technology use significantly improved students' performance in Mathematics, as evidenced by the 8.79% increase in mean scores post-intervention.

### **Implications for STEM Education**

The findings of this study have important implications for the teaching of Mathematics and other STEM subjects. The positive impact of the ACT pedagogy on students' performance demonstrates the potential of active, technology-enabled learning strategies to enhance student outcomes in traditionally challenging subjects. Given the growing importance of STEM education in today's digital economy, implementing pedagogies like ACT could help address the widespread disengagement and underachievement in STEM fields.

Additionally, the study's findings support the broader argument for integrating 21st-century skills into the curriculum. By fostering collaboration, creativity, and critical thinking, the ACT model not only improves students' understanding of mathematics but also prepares them for the complex problem-solving tasks they will encounter in the future workforce.

### **CONCLUSION**

This study set out to evaluate the effectiveness of the Activated Classroom Teaching (ACT) pedagogy in improving students' performance in Mathematics. The findings clearly indicate that the ACT model, which focuses on active learning and technology integration, significantly enhances students' engagement and academic outcomes. By shifting the focus from passive consumption to active content production, the ACT pedagogy fosters a deeper understanding of mathematical concepts and equips students with essential 21st-century skills. The results of this study show that active learning strategies, specifically those that leverage technology, can play a critical role in addressing the challenges associated with traditional mathematics education. The increase in student performance, reduction in failure rates, and development of problem-solving skills underscore the value of incorporating active pedagogies into STEM education.

### **FUTURE RESEARCH DIRECTIONS**

While the findings of this study are promising, future research could explore the long-term impact of ACT pedagogy on student performance across different age groups and educational settings. Additionally, further studies could investigate how the model can be adapted to other STEM subjects, such as science and engineering, to broaden its applicability and effectiveness. Ultimately, the success of the ACT model in this study highlights the need for continued innovation in educational practices, particularly in integrating technology and active learning approaches. By embracing these pedagogical shifts, educators can better equip students to succeed in an increasingly complex and technology-driven world.

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<sup>27</sup> Garber, "Death by Powerpoint"; Draper, Cargill, and Cutts, "Electronically Enhanced Classroom Interaction."

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