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EFFECT OF FLIPPED CLASSROOM LEARNING ON PERFORMANCE IN MATHEMATICS AMONG LEARNERS IN THIKA HIGH SCHOOL FOR THE VISUALLY IMPAIRED, KENYA

Jackline Ncekei[1i],
Margret Murugami[2],
Becky Isanda[3]
[1]Master's Student,
Department of Special Needs Education,
School of Education,
Kenyatta University,
Nairobi, Kenya
[2]Senior Lecturer
Department of Special Needs Education,
School of Education,
Kenyatta University,
Nairobi, Kenya
[3]Lecturer,
Department of Special Needs Education,
School of Education,
Kenyatta University,
Nairobi, Kenya

Abstract:
Flipped Classroom Learning (FCL) has emerged as an inclusive, student-centered pedagogical model that shifts direct instruction beyond the classroom and dedicates in-class time to active, collaborative learning. This study investigated the effect of FCL on mathematics performance among learners with visual impairment at Thika High School for the Visually Impaired, Kenya. Adopting a quasi-experimental research design, the research involved 40 Form Two students, six mathematics teachers, and one head teacher. Stratified and purposive sampling techniques were used to assign learners to treatment and control groups. The treatment group engaged in audio-based pre-class content and interactive in-class activities over six weeks, while the control group continued with conventional instruction. Quantitative data were collected via pre- and post-tests, and qualitative data through teacher interviews and learner observations. The findings revealed no significant difference in pre-test scores between the groups ($p = 0.966$), confirming initial parity. However, post-test results indicated a statistically significant difference in mathematics performance between the treatment group ($M = 13.8$, $SD = 3.27$)

[i] Correspondence: email jacklinemiriti02@gmail.com

and the control group (M = 9.7, SD = 4.33), with ANOVA results yielding F(1,38) = 11.419, p = 0.002. These results demonstrate that FCL significantly enhances mathematics performance among learners with visual impairment. The study concludes that FCL, when adapted with accessible audio materials and collaborative instructional strategies, can effectively support inclusive mathematics education. It recommends equipping schools with assistive technologies, training educators in FCL pedagogy, and extending future research across subjects, educational levels, and disability categories to enhance educational equity.

Keywords: flipped classroom learning, learning performance, visually impaired learners, mathematics

1. Introduction

Flipped Classroom Learning (FCL) represents a pedagogical inversion of traditional instruction, where content delivery occurs primarily through digital resources for pre-class study, transforming classroom time into an active, collaborative learning space. This approach repositions direct instruction from the group setting to individual study, enabling class sessions to focus on dynamic application of concepts through guided problem-solving, discussions, and student-centered activities that foster critical thinking (Flipped Learning Network [FLN], 2014; So & Brush, 2008; Strayer, 2012). By restructuring the learning environment in this way, FCL shifts the educator's role from knowledge transmitter to learning facilitator while promoting deeper cognitive engagement.

The role of the teacher shifts from a primary source of knowledge to that of a facilitator who supports learners in their knowledge construction. According to Castaneda *et al.* (2025), the FCL model is inclusive and can be adapted to support all learners, including those with visual impairments, by fostering independence in knowledge acquisition and enhancing critical thinking. This inclusivity contributes to improved performance, particularly in Mathematics.

Globally, flipped classroom learning has been increasingly adopted to complement conventional teaching methodologies. Empirical evidence suggests that FCL positively influences academic performance across various subjects. A systematic review by Fernández-Martín *et al.* (2020) found that FCL enhances student engagement, self-regulation, collaboration, motivation, and autonomy. These attributes contribute to improved knowledge retention, positive attitudes toward learning, and increased academic achievement, particularly in Mathematics. In the United States, the implementation of the World Wide Web Consortium (W3C) accessibility standards has ensured that learners with disabilities can access digital content effectively. Technologies such as screen readers, voice command systems, and touch-based interfaces facilitate access to instructional materials for learners with visual impairments (Media Access America [MAA] & Hollier, 2016). These technologies have enabled the creation of

inclusive content within the FCL framework, thereby promoting independent learning and flexible instructional environments that contribute to improved academic outcomes. Klingenberg *et al.* (2020), in a systematic review of digital learning in Mathematics for learners with severe visual impairments, concluded that interactive flipped learning environments serve as valuable tools for improving Mathematics performance. Similarly, Fernández-Martín, *et al.* (2020), in a comprehensive review of FCL implementation in higher education in Spain, reaffirmed that student engagement in flipped classrooms enhances autonomy and motivation, which translates into better performance in Mathematics. Empirical studies in Asia further support these findings. In Taiwan, Bhagat, *et al.* (2016) conducted a quasi-experimental study that demonstrated significantly higher Mathematics performance among students exposed to FCL compared to those taught through conventional methods. Additionally, Wei *et al.* (2020) reported notable improvements in Mathematics performance among sixth-grade students in Mainland China who were taught using FCL strategies.

The effectiveness of FCL in Mathematics has also been explored in Africa. In Cameroon, Mboshi (2018) examined instructional practices in inclusive settings and identified techniques such as read-aloud, guided learning, and assistive technologies as effective for learners with visual impairments. However, the study recommended integrating FCL to further enhance academic achievement. In Nigeria, Makinde (2020) conducted a quasi-experimental study which demonstrated that FCL, as a learner-centered instructional strategy, significantly improved Mathematics performance among secondary school students.

In Kenya, FCL has been implemented with encouraging results. Kithinji (2020), in a quasi-experimental study, reported that FCL positively influenced academic achievement in science among primary school learners. Despite these findings, the study highlighted the scarcity of FCL research in Kenya and recommended broader application across subjects and further investigation. In agreement, Ireri and Omwenga (2016) asserted that mobile learning integrated into a flipped classroom model bridges learner entry behavior gaps and enhances performance. However, neither of these studies specifically addressed learners with visual impairments. Against this backdrop, the current study aims to examine the effect of flipped classroom learning on Mathematics performance among learners with visual impairment at Thika High School for the Visually Impaired, Kenya.

2. Statement of the Problem

Mathematics is an important subject at all levels of schooling worldwide. Despite the subject's strategic relevance, learners with visual impairment have continued to perform poorly in Kenyan national examinations (Mwangi, 2019; Republic of Kenya, 2018, 2020). In Thika High School for the visually impaired, Mathematics performance has produced a mean score of less than 3.5 points out of the possible 12 points for the last six years. This dismal performance makes further education and employment in STEM sectors

extremely difficult for learners with VI. Studies reveal that learners with VI perform poorly in Mathematics owing to insufficient assistive technology and instructors' unwillingness to implement suitable teaching strategies such as flipped classroom learning (Mwangi, 2019). In addition, Kithinji's (2020) study established that FCL has been used for learners without disabilities but minimally for learners with VI. Besides, limited studies have been done in Kenya on the use of the FCL approach in teaching Mathematics to learners with VI (Kithinji 2020). The low performance in Mathematics of learners with VI prompted the researcher to find out whether flipped classroom learning could help remedy this situation.

2.1 Objective of the Study

The specific objective that guided this study was to determine the effect of Flipped Classroom Learning on performance in Mathematics among learners with Visual impairment.

2.2 Hypothesis of the Study

This study sought to test the null hypothesis *"There is no statistically significant difference in performance between learners exposed to FCL and those who were not".*

3. Methodology

This study adopted a Quasi-experimental research design enriched with descriptive methods to collect qualitative and quantitative data. A quasi-experimental research approach was utilized in this study because the researcher introduced a new treatment, FCL, to learners with VI. Specifically, the study used the Pre-test, Post-test design where two groups were involved: the experimental group and the control group. According to White and Shagun (2014), in quasi-experimental designs, a control group with the same fundamental characteristics as the treatment group is explored, and the treatment group can be manipulated to discover the causal effect. The researcher, through the experiment, gathered quantitative data by providing a pre-test to the learners and compared the results with the post-test after giving the treatment using flipped classroom learning. This determined how effective the treatment was. After six weeks of administering the FCL treatment, the researcher administered a posttest to the chosen treatment group to see if FCL resulted in improved performance in mathematics among learners with VI. Besides, the descriptive design tool was used in gathering teachers' opinions on the teaching strategies used in teaching learners with VI, as well as observing learners during FCL treatment, as indicated in Table 1.

Table 1: Quasi-Experimental Research Design

P	T_1	X	T_2

P- Sample population
T1- Pretest
X- Treatment
T2- Posttest

Qualitative data was obtained through an observation schedule for the learners and an interview guide for the Mathematics teachers, where the researcher was able to see different traits exhibited by the learners in relation to using FCL and their opinions towards using FCL and performance in Mathematics. In the present study, a quasi-experimental design was appropriate as the research aimed to collect raw quantitative data of learners' performance using a pretest and posttest design before and after the introduction of the FCL treatment. The researcher also aimed to collect raw qualitative data on different strategies teachers use in teaching Mathematics and learners' involvement when using FCL.

3.1 Target Population

The study targeted 102 form two learners in Thika High School for the VI, all six teachers teaching Mathematics in Thika High School for the VI, because they use different teaching strategies when teaching Mathematics to learners with VI, and one head teacher.

3.2 Sampling Technique and Sample Size

The researcher used a purposive sampling technique to select teachers who teach Mathematics in Thika High School for the VI. The stratified sampling was applied in selecting learners with VI based on the criteria of female and male status. From the different strata, a simple random sampling technique was utilized to select two learners with VI and use braille to read and write, for the experimental and control group, to give the participants an equal chance of participation in the study to investigate the influence of flipped classroom learning on performance in Mathematics among learners with VI. This study comprised a sample size of one Head teacher, six teachers teaching Mathematics in the school and 40 form two learners, representing (39.22%) of the 102 form two learners with VI learning Mathematics. The sample size of 47 represented 43.12% of the target population of 109 respondents, as shown in Table 2.

Table 2: Target Population

Types of respondents	**Target Population**	**Number sampled**
Head teacher	1	1
Teachers of Mathematics	6	6
Learners	102	40
Total	**109**	**47**

4. Results and Discussion

4.1 Results

The objective of this study was to investigate the effect of flipped classroom learning on performance in Mathematics among learners in Thika High School for the visually impaired, Kenya.

The researcher administered a pre-test and a post-test six weeks apart. The pre-test was conducted to identify each learner's areas of weakness across different topics and to ensure that participants in both the treatment and control groups had similar entry behaviors before the FCL treatment was introduced to the treatment group. During this time, the control group continued with regular instruction. Both groups, treatment and control, took the pre-test, and their scores are presented in Table 3.

Table 3: Pre-Test Scores

Range	**O – 5**	**6 – 10**	**11 – 15**	**16 – 20**	**21 – 25**
Control Group	4	12	3	1	0
Treatment Group	6	8	5	1	0

Table 3 shows that, in the control group, 4 learners scored between 0 to 5 marks, 12 learners scored between 6 to 10 marks, 3 learners scored 11 to 15 marks and 1 learner scored between 16 to 20 marks out of 25 maximum marks. Table 3 also show that, on the treatment group, 6 learners scored between 0 to 5 marks, 8 learners scored between 6 to10 marks, 5 learners scored between 11 to 15 marks, 1 learner had a score between 16 to 20 marks out of the 25 maximum marks. none of the learners in either group scored between 21 to 25.

The pretest analysis for both the treatment and the control groups' findings were scaled as shown in Table 4.

Table 4: Analysis of pre-test

Pre-test				
Groups	**Count**	**Sum**	**Mean**	**Variance**
Control Group	20	163	8.15	13.81842105
Treatment Group	20	162	8.10	12.62105263

Table 4 shows that the control group scored a total of 163 marks out of all the 20 learners' scores and a mean of 8.15. Table 4 further shows that the treatment group had a sum of 162 marks and a mean score of 8.10 of all the 20 learners. The results in Table 4 reveal that the means of the two groups were almost equal, an indicator of similar entry behaviors for the learners who participated in the study. To determine whether there was a statistically significant difference in learners' academic performance between the control and experimental groups in the pre-tests, the mean scores were analyzed using the Analysis of Variance (ANOVA) test. The findings of the test are systematically shown in Table 5.

Table 5: Pre-test ANOVA

Pre-Test ANOVA Analysis						
Source of Variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	0.025	1	0.025	0.002	0.966	4.098
Within Groups	502.350	38	13.220			
Total	**502.375**	**39**				

Table 5 shows that the one-way ANOVA statistic F (1, 38) = 0.001 with a P-value of 0.966, which exceeded the confidence threshold of P=0.05. This implies that prior to the implementation of the treatment intervention, there was no statistically significant difference in the academic achievement levels of learners between the treatment and the control groups. The pre-test results demonstrated a normal distribution at the outset of the study, indicating that both groups were comparable in terms of their entry behaviour, thus forming a baseline of parity that supports the validity of subsequent comparisons following the intervention.

After the pre-test, both groups were taught the same topics for six weeks. The treatment group was taught using the FCL strategy as an intervention, while the control group was taught in the same way they were taught earlier. The FCL treatment involved learner-centred activities which encouraged critical thinking. the researcher recorded audio which learners listened to during out-of-class activities. The audios were accompanied by questions, which were answered in groups later. Activities in class included focus group discussions, asking and answering questions, presentations from the groups, exploration, and independent problem-solving.

After six weeks, a post-test was administered to both groups to assess the effect of flipped classroom learning activities on performance in mathematics. The results were summarized as shown in Table 6.

Table 6 : Post-Test Scores

Range	**0 – 5**	**6 – 10**	**11 – 15**	**16 – 20**	**21 – 25**
Control Group	4	7	7	2	0
Treatment Group	0	2	13	4	1

Table 6 presents the outcomes of the post-test assessment. In the control group, four learners achieved scores within the range of 0 to 5 marks, seven learners obtained scores between 6 and 10 marks, seven learners scored within the range of 11 to 15 marks, and two learners achieved scores between 16 and 20 marks out of a maximum of 25 marks. Notably, none of the learners in the control group attained scores within the range of 21 to 25 marks. In contrast, within the treatment group, none of the learners scored between 0 and 5 marks; two learners achieved scores within the range of 6 to 10 marks, thirteen learners scored between 11 and 15 marks, and four learners obtained scores within the range of 16 to 20 marks out of the maximum 25 marks. Additionally, one learner in the treatment group achieved a score within the range of 21 to 25 marks.

The post-test analysis for both treatment and the control groups' findings were scaled as shown in Table 7.

Table 7: Posttest Analysis

Post-Test Mean Scores					
Groups	**Count**	**Sum**	**Mean**	**Variance**	**STD Dev**
Control Group	20	194	9.700	18.747	4.330
Treatment Group	20	276	13.800	10.695	3.270

Table 7 shows that out of the possible 25 marks, 20 learners who participated in the treatment group had a Mean of 13.8 and SD 3.27. The mean score for the 20 learners in the control group was M= 9.7 and SD= 4.33. When comparing the two means, the treatment group mean was somewhat higher than the control group mean. This revealed the strength of FCL treatment in improving Mathematics outcomes of learners with VI.
To determine if there was a statistically significant difference in learner academic performance between the treatment and control groups in the post-test., ANOVA statistics were used to generate inferential statistics, and the results were summarized in Table 8.

Table 8: ANOVA Post-Test

ANOVA Post Test						
Source of Variation	**SS**	**Df**	**MS**	**F**	**P-value**	**F crit**
Between Groups	168.100	1	168.100	11.419	0.002	4.098
Within Groups	559.400	38	14.721			
Total	**727.500**	**39**				

P-Value (α) = 0.05

Table 8 shows a one-way ANOVA statistic F (1, 38) =11.419, and a p-value = 0.002, which was less than the confidence level of P=0.05. This finding indicates that a statistically significant difference in mathematics performance was evident among learners who were taught utilizing the Flipped Classroom Learning (FCL) approach and those who were taught using conventional teaching methods. This outcome suggests that the structured learning activities implemented within the FCL framework, which emphasize active engagement, collaborative interaction, and learner-centered instruction, contributed to an enhancement in learners' performance in mathematics. The results demonstrate that the pedagogical strategies inherent in FCL, such as pre-class preparation, in-class problem-solving, and the use of technology-mediated resources, effectively supported learners in achieving higher levels of academic success compared to traditional teaching methods. Thus, the null hypothesis ($H0_1$: *There is no statistically significant difference in performance between learners exposed to FCL and those who were not*) is rejected, as the significant p-value (p = 0.002) indicates superior performance among FCL-exposed learners. The alternative hypothesis is accepted, confirming that FCL learners performed statistically better than those taught conventionally.

4.2 Discussion

The study examined the impact of flipped classroom learning (FCL) on Mathematics performance among learners at Thika High School for the Visually Impaired, Kenya. Pretest results confirmed baseline equivalence between the control (mean = 8.15) and treatment groups (mean = 8.10), with ANOVA analysis ($F = 0.002$, $p = 0.966$) indicating no significant initial differences, as shown in Table 5. After the six-week FCL intervention, featuring pre-class audio lectures, guided questions, group discussions, and problem-solving activities, the treatment group exhibited a marked improvement, achieving a mean score of 13.8 compared to the control group's 9.7, as shown in Table 8. Notably, 90% of FCL learners scored ≥11 marks, with one reaching the 21–25 range, while only 45% of the control group attained similar scores, as shown in Table 7. The ANOVA test affirmed the statistical significance of this difference ($F = 11.419$, $p = 0.002$), rejecting the null hypothesis that FCL had no effect.

These findings in this study align with existing literature on FCL's effectiveness. For instance, a quasi-experimental study in Nigeria by Makinde (2020) similarly found that FCL's learner-centered approach enhanced mathematics performance. The audio-based materials in this study, adapted for learners with visual impairment, facilitated flexible learning, reinforcing Fernández-Martín *et al.*'s (2020) assertion that FCL fosters self-regulation and collaborative learning, thereby improving mathematical understanding. Additionally, Fatimah *et al.* (2022) emphasized that FCL's active engagement strategies lead to higher academic achievement, further supporting this study's outcomes. Collectively, these results demonstrate that tailored FCL methodologies can significantly enhance mathematics performance for learners with visual impairment, provided appropriate adaptations and structured learner-centered activities are implemented. This underscores the potential of FCL as an inclusive pedagogical strategy in special needs education.

5. Conclusion and Recommendations

5.1 Conclusion

This study empirically demonstrates that the Flipped Classroom Learning (FCL) model, when pedagogically adapted for learners with visual impairment through audio-based instructional media and structured collaborative in-class activities, yielded statistically significant improvements in mathematics performance at Thika High School for the Visually Impaired. Comparative analysis of post-test results revealed that the experimental (FCL) group exhibited superior academic achievement relative to the control group, as evidenced by higher mean scores (M=13.8 vs. M=9.7) and a greater proportion of learners attaining upper-quartile performance thresholds. These findings validate FCL as an efficacious and transformative instructional strategy within inclusive education frameworks, particularly when integrated with assistive technologies and constructivist learning methodologies that foster active engagement, self-regulated learning, and peer-mediated knowledge construction. To optimize scalability, future

implementation should prioritize systemic enablers, including teacher professional development in adaptive pedagogies, equitable access to assistive technologies, and institutional support for differentiated learning infrastructures. This study contributes to the discourse on inclusive education by providing empirical evidence on the viability of technology-mediated pedagogical innovations while underscoring the need for further longitudinal research on sustainable adoption models in disability-inclusive educational settings.

5.2 Recommendations

This study recommends that governments improve access to technology-based learning materials for learners with visual impairment (VI) and ensure schools have essential infrastructure like electricity and internet. Additionally, the Ministry of Education (MoE) should train teachers in modern strategies such as Flipped Classroom Learning (FCL) to enhance instruction for VI learners, extending this training to curriculum developers to promote wider adoption. This need is highlighted by findings showing that many teachers lack familiarity with FCL. For future research, the study suggests replicating this investigation across different education levels and examining FCL's effectiveness in Mathematics for learners with other disabilities, including physical impairments, autism, and hearing impairment. Further studies could also explore FCL's application in other subjects for VI learners and assess long-term knowledge retention and scalability in similar settings.

Conflict of Interest Statement

The authors declare no conflicts of interest.

About the Author(s)

Jackline Ncekei is Master of Education student at the Department of Early Childhood and Special Needs Education in the School of Education, Kenyatta University, Kenya specialising in in Special Needs Education (Visual Impairment option). She is currently serving as a Teacher of Mathematics, Business and Special Needs Education at the Kenyatta University Junior School, Kenya. Her hobby is reading, research and supporting learners with disabilities.

Dr. Margaret Murugami is Senior Lecturer in the Department of Early Childhood and Special Needs Education, Kenyatta University, Kenya. Her research interests are in Developmental Disabilities and Visual Impairment.

Dr. Becky Isanda is Lecturer in the Department of Early Childhood and Special Needs Education, Kenyatta University, Kenya. Her research interests are in Disability Studies and Hearing Impairment.

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