EFFECTS OF ROTATION-BASED BLENDED LEARNING MODEL ON MATHEMATICS ACHIEVEMENT AND SELF-STUDY SKILLS AMONG SECONDARY SCHOOL STUDENTS

BY

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Abstract

This study examined the effectiveness of a blended learning model on mathematics achievement and self-study skills among secondary school students in Ekiti State, Nigeria. The study was motivated by persistent difficulties in students' mathematical understanding, problem-solving performance, and independent learning habits, particularly within conventional teacher-centred instructional settings. A pretest–posttest quasi-experimental design was adopted. The sample comprised 95 Senior Secondary II students drawn from two intact classes in an urban secondary school using purposive sampling technique. Data were collected using a 40-item Mathematics Achievement Test and a 20-item Self-Study Skills Scale, with reliability coefficients of 0.79 and 0.85 respectively. Descriptive statistics and analysis of covariance were used to analyse the data. Findings showed that students exposed to blended learning recorded higher gains in mathematics achievement than those taught through conventional instruction, with the experimental group improving from a pretest mean of 61.25 to a posttest mean of 85.14. Similarly, self-study skills improved markedly among students in the blended learning group, rising from a mean of 3.12 to 4.18. The findings suggest that a carefully structured blended learning model supported by teacher guidance and purposeful digital activities can strengthen the achievement and self-study skills among secondary school learners of mathematics.

Keywords: blended learning, mathematics achievement, self-study skills, secondary school students, rotation model.

Introduction

Mathematics is a core subject in secondary school yet many students continue to face problems in understanding concepts, problems solving and motivation, resulting in either poor performance and limited development of self-regulated learning (Egara, 2024; Sбez-Delgado et al., 2023). These difficulties are particularly consequential at the senior secondary school level, where students are expected to prepare for internal and external certification examinations while also preparing them for future participation in STEM pathways. It has been observed by the researchers that in many secondary school classrooms, Mathematics instruction remain largely teacher centred with lessons

often emphasizing demonstration, note copying, textbook exercise and teacher-controlled practices. While, these approaches may support content coverage, they often do not provide sufficient opportunities for differentiated learning, repeated practice, independent exploration of mathematical ideas and immediate feedback. Moreover, students who require additional time to process abstract concepts may fall behind while those who need more challenging tasks may also not adequately covered. Similarly, the development of self-study skills such as goal setting, time management, resource use, persistence and self-assessment do not often receive explicit attention with these approaches whereas these skills are important skills that should not be overlooked at this level of education (Зobanoğlu & Gıkalp, 2026; Maoto, 2023). This has spurred researchers to take a look at novel pedagogies such as blended learning to improve content understanding and learner autonomy (Egara, 2024; Abdissa et al., 2025; Komala & Monariska, 2023).

Blended learning is a method that combines traditional teaching and online teaching in ways that maintain the effectiveness of classroom learning while providing opportunities for self-paced learning, practice, and feedback (Ahmed 2025, Yu et al 2025). Blended learning in mathematics can help with the use of visual representations, interactive practice, quizzes, explanation through videos, collaborative problem solving as well as differentiated reinforcement. This model allows the students to have access to digital resources for use as a way of independently exploring while at the same time having direct guidance from the teacher, as well as peer-to-peer interaction in the classroom. This may help to address some of the common issues in mathematics education such as lack of engagement, limited personalization, and difficulties in developing autonomous learning habits (Attard & Holmes, 2020; Tong et al., 2022). The model is particularly promising when experience in digital activities is not used as a substitute for teaching, but as part of a deliberate pedagogical design that improves explanation, practice, assessment, feedback, and engagement.

The rotation model is one of the blended learning modalities for secondary school contexts with limited arrangements. With respect to this model the student switches between classroom lead by a teacher and organised digital or self-paced learning stations. As a result, the teacher can still provide useful instruction while students work independently with the digital material, worksheets, quizzes, and collaborative learning tasks. In resource poor settings, the rotation model can be easier to implement compared to fully online or highly flexible models because devices, internet access, and teacher supervision can be organised in the school ecosystem.

In many schools, access to digital devices, stable internet connectivity, electricity, and quiet home study spaces cannot be assumed. At the same time, students increasingly encounter digital technologies in informal learning and examination preparation. A blended model that is school-supported and teacher-mediated may therefore provide a more equitable way of introducing digital learning into mathematics instruction.

Existing studies suggest that blended learning can improve mathematics achievement and related learner outcomes. Tong et al. (2022), found that a blended learning approach improved students' achievement, self-study skills, and learning attitudes in secondary mathematics. Abdissa et al. (2025) similarly reported positive effects of a lab rotation blended learning model on secondary school students' mathematics achievement. In Nigeria, Egara and Mosimege (2024) found that blended learning improved learners' mathematics achievement and retention. Meta-analytic evidence also indicates that blended learning can have positive effects on mathematics performance, although the magnitude of the effect varies according to implementation model, educational level, digital platform, and instructional quality (Putri, 2025; Setiawan et al., 2022).

The self-study skills (independent learning, time management, use of resources and self-assessment) are very important at secondary level because students prepare for examination and other learning requirement necessary for life (Зobanoğlu & Gıkalp, 2026; Maoto, 2023). Conventional teaching strategies, which are often controlled by a teacher are usually ineffective in developing these skills. Studies (Abdissa et al., 2025; Egara &

Mosimege, 2024) conducted in various developing countries and regions within secondary mathematics contexts reveal that blended learning results in greater achievement and retention than other traditional approaches. The effect sizes imply they possess substantial practical significance. Various meta-analytic reviews have also confirmed that blended learning is effective in improving mathematics performance at all educational levels the secondary level. However, heterogeneity exists because of the way the blended learning was implemented (Wu et al., 2025; Putri, 2025).

The primary purpose of this study was to determine whether the use of a blended learning model has an effect on the achievement and self-study abilities of second-year students in mathematics compared with face-to-face learning. For this purpose, a research question was raised and two hypotheses were formulated.

Research Question: To what extent does rotation-based blended learning models affect mathematics achievement and self-study skills among secondary school students relative to conventional classroom instruction?

Hypotheses

1: There is no significant difference in pretest and post-test mathematics achievement scores of students taught mathematics using rotation-based blended learning models and those taught using traditional methods.

2: There is no significant difference in pretest and posttest self-study skills scores of students in the experimental and control groups

Literature Review

Blended learning refers to the intentional combining of face-to-face instruction with online or digitally-facilitated learning experiences (Graham, 2006; Hrastinski, 2019). The essence of blended learning is not merely to deploy technology in the instruction but to craft experiences that integrate teacher explanation, learner self-directedness, peer interaction, instant feedback and digital resources. In mathematics education, effective integration can be particularly valuable, as many students benefit from repeated practice, visual representations, detailed explanations, diagnostic feedback, and opportunities to revisit challenging concepts independently (Tong et al., 2022; Abdissa et al., 2025; Egara, 2024).

Various blended learning models have been successfully used in school mathematics. Some of these models include flipped model, flex model, and the Lab or station rotation model. In the flipped classroom model, students view instructional video or materials ahead of class time and class time is devoted to problem solving, discussion and application. For the flex model, online learning is the primary mode of instruction, with teachers offering support when necessary. In the lab rotation or station rotation model, students switch between teacher-led learning and digital learning or self-directed lesson activities (Mahjudin et al., 2021). The current study emphasizes upon the rotation model since this model is more practicable at secondary schools where the digital devices could be shared and teacher intervention is still considerably required.

Blended Learning and Achievements in Mathematics

Most research findings indicate that blended learning can enhance the mathematics achievement of learners if the design is appropriate and instructionally aligned. According to Tong et al. 2022, students who are taught through a blended learning model perform better in mathematics achievement rather than conventional instruction. Their research discovered that not only did students' self-study skills improve, but their learning attitude as well. Hence, blended learning may affect the cognitive and affective dimensions of learning mathematics. Abdissa et al. (2025) reported similar evidence in Ethiopia, where students on a lab rotation blended learning model attained significantly higher mathematics scores than students on a traditional classroom group. Similarly, Al-Ali (2024) shared that Jordanian high school students made significant gains in achievement and knowledge retention in a blended learning intervention. Also, the prior research of Lin et al. (2017) revealed that its use in the junior high had a positive impact on mathematical performance and attitude. According to Egara and Mosimege (2024), learners in secondary school taught by means of blended learning had better achievement and retention of Mathematics than those taught through conventional method. This

is significant as it suggests that blended learning does not only work in environments where technology is abundant but may work in the African context where technology is lacking. However, the success of these models depends on the quality of instructional planning, the conditions of access, teacher competences and the digital task-curriculum fit.

Blended learning had a positive effect on students' mathematical ability (Setiawan et al. 2022). Furthermore, Putri (2025) illustrated that blended learning has a considerable overall positive effect on mathematics achievement, and this was evident in the empirical studies. Outcomes may differ depending on learning platform, school level, duration of intervention, topic of mathematics, preparation of teacher and fidelity of implementation. The workings of a particular blended model in a particular context can only be ascertained through localized classroom-based studies.

Blended Learning and self-study skills.

Successful mathematics learning requires self-study skills so students can practice alone, make use of learning resources, manage time, evaluate solutions and rectify misconceptions. There exists a strong relationship between these skills and self-regulated learning. In typical classrooms, students may depend on the teacher's explanations and seldom have the opportunity to plan/monitor their learning. In contrast, blended learning can offer opportunities to engage independently with materials or online quizzes, worksheet feedback and revision tasks.

According to Tong et al. (2022), blended learning was found to enhance students' self-study skills because students were obliged to interact with learning materials outside of ordinary lesson explanation. The blend-learning environments were reported to support self-regulated and self-directed learning skills (Uz and Uzun, 2018). In addition, a meta-analysis carried out by Guntur and Purnomo (2024) shows positive impacts of self-regulated learning interventions in online and blended environments. Zhao et al. (2025) provided additional evidence that self-regulated learning strategies are related to academic performance in online and blended learning.

Literature reveals that blended learning often positively influences fostering learner attitudes, motivation and engagement towards mathematics. According to Tong et al. (2022) and Lin et al. (2017), the ability to attend classes flexibly as well as interact with peers efficiently in a blended environment enhanced the learning attitudes and reduced the anxiety levels of online learners. Moreover, students in mixed groups reported more satisfaction, greater confidence, and more intrinsic motivation due to the self-paced practice and multimedia resources (Attard & Holmes, 2020).

It appears that blended learning can influence study behaviours of learners which further enhance their performance in mathematics. Mathematics concepts are more likely to be secured by students who learn to manage their time, go back over explanations, attempt practice questions, use feedback and monitor their own progress. The benefits are dependent on the way the blended model is implemented. When left to their own devices online, students in blended learning may reproduce or deepen existing inequalities. If students participate in formal, supervised digital activities, which are associated with classroom support and promote blended learning, they are likely to get better study habits.

Implementation Issues in Resource-Constrained Contexts

The effectiveness of blended learning cannot be separated from implementation conditions. UNESCO (2023) cautions that educational technology should be judged not by novelty, but by relevance, equity, scalability, and sustainability. In resource-constrained contexts, students may differ widely in access to devices, internet connectivity, electricity, and home study support. Teachers may also differ in digital competence and confidence. These conditions matter because blended learning can either broaden access to learning opportunities or widen inequalities if poorly planned.

For this reason, school-supported rotation models may be especially useful. They allow digital learning to occur under teacher supervision and within scheduled learning time. Students can share school-based devices or rotate through stations, reducing dependence on home access. The teacher remains available to clarify misconceptions and provide support. Such

a model is not a technology replacement strategy; it is a pedagogical arrangement that uses digital resources to strengthen explanation, practice, feedback, and student responsibility.

Gap in the Literature

The reviewed literature indicates that blended learning can improve mathematics achievement and may support self-study skills. However, three gaps justify the present study. First, there remains a need for more context-specific evidence from Nigerian secondary schools. Second, fewer studies examine achievement and self-study skills together. Third, blended learning studies sometimes use broad labels without clearly identifying the specific model implemented. This study contributes by evaluating a rotation-based blended learning model in a Nigerian secondary school and by examining both mathematics achievement and self-study skills using a quasi-experimental design.

Methodology

The study used a quasi-experimental pretest-posttest non-equivalent control group. Two intact classes were selected: one as the experimental group and the other as the control. The sample consisted of 95 students aged 14–17 years. Two intact classes were purposively sampled from an urban secondary school to avoid disruption and ensure practicality. The experimental group was treated using a rotation-based blended learning model. During each instructional cycle, students moved between teacher-led classroom instructions and structured self-paced learning activities. The digital component included instructional videos, online or offline quizzes, worksheets, guided practice tasks, and discussion prompts. The face-to-face component included teacher explanation, worked examples, small-group problem solving, feedback, and individual support. The control group were taught conventionally over the same eight-week period. To support uniformity, both groups covered the same mathematics content and received equivalent instructional time.

Two instruments were used for data collection: the Mathematics Achievement Test and the Self-Study Skills Scale. The Mathematics Achievement Test was a 40-item multiple-choice test developed from the secondary school mathematics curriculum and the topics covered during the study. MAT was reviewed by mathematics education experts for content validity, curriculum alignment, clarity, and appropriateness for Senior Secondary II students. A pilot test was conducted before the main study, and a test re-test reliability coefficient of 0.79 was obtained.

The Self-Study Skills Scale was a 20-item Likert-type questionnaire designed to measure students' independent learning behaviours. The scale covered goal setting, time management, resource use, persistence, self-monitoring, and self-assessment. Responses were scored on a five-point scale ranging from strongly disagree to strongly agree. Higher scores indicated stronger self-study skills. The instrument was reviewed for face and content validity and pilot-tested for internal consistency. Cronbach's alpha was .85, indicating acceptable reliability.

Data were analysed using descriptive statistics and analysis of covariance. Means, standard deviations, mean gains, and within-group effect sizes were used to describe changes in mathematics achievement and self-study skills. ANCOVA was used to test the hypotheses because it allowed comparison of posttest scores between the experimental and control groups while controlling for pretest scores. The experimental group was treated using a rotation-based blended learning model. During each instructional cycle, students moved between teacher-led classroom instructions and structured self-paced learning activities. The digital component included instructional videos, online or offline quizzes, worksheets, guided practice tasks, and discussion prompts. The face-to-face component included teacher explanation, worked examples, small-group problem solving, feedback, and individual support. The control group were taught conventionally over the same eight-week period. To support uniformity, both groups covered the same mathematics content and received equivalent instructional time.

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Results

Descriptive analysis

Research Question: To what extent does the implementation of rotation-based blended learning model affect mathematics achievement and self-study skills among secondary school students relative to conventional classroom instruction?

To assess the extent to which the implementation of rotation-based blended learning model affect mathematics achievement and self-study skills among secondary school students, the results of the pretest and posttest scores of the students in the experimental group were compared with the results of students in the control group descriptively. As shown in Table 1, the pretest results indicate that the experimental and control groups were generally similar prior to the intervention. With regards to the mathematics achievement, pretest mean of the experiment group was 61.25 (SD = 7.82) and the control group was 60.98 (SD = 7.65). The control and experimental group having a mean score of 3.08 (SD = 0.71) and 3.12 (SD = 0.68) respectively on the pretest of self-learning skills.

Table 1: *Pretest and Posttest Descriptive Statistics for Mathematics Achievement and Self-Study Skills*

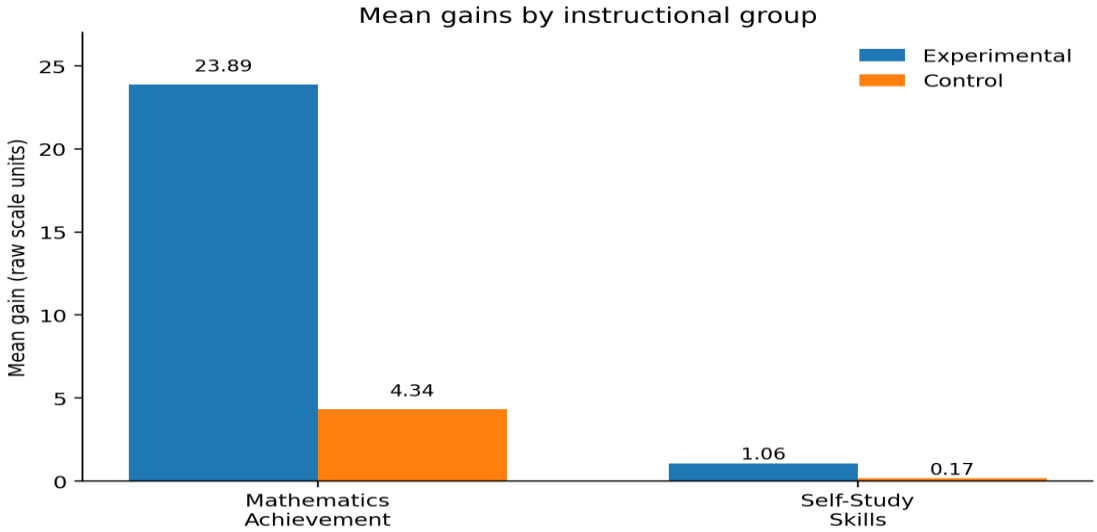
Variable	Group	N	Pretest M (SD)	Posttest M (SD)	Mean gain	Within-group d
Mathematics achievement	Experimental	48	61.25 (7.82)	85.14 (10.95)	23.89	2.41 (very large)
Mathematics achievement	Control	47	60.98 (7.65)	65.32 (9.18)	4.34	0.50 (medium)
Self-study skills	Experimental	48	3.12 (0.68)	4.18 (0.72)	1.06	1.50 (large)
Self-study skills	Control	47	3.08 (0.71)	3.25 (0.69)	0.17	0.24 (small)

After the testing, the experimental group improved a lot more than the control group. As far as mathematics achievement was concerned, the experimental group was found to increase from 61.25 to 85.14 which result in a mean gain of 23.89 points whereas the control group was found to increase from 60.98 to 65.32 which result in a mean gain of 4.34 points. The within-group Cohen's d values were 2.41 (experimental group) and 0.50 (control group), showing very large

improvement in the blended learning condition and medium improvement in the conventional classroom condition, respectively. The result of the study - For self-study skills, the experimental group's score increased from 3.12 to 4.18 with a mean gain score of 1.06. The score of the control group increased from 3.08 to 3.25 with a mean gain score of 0.17. The blended learning group experienced a large effect of blended learning on self-regulation skills (d = 1.50), while the control group experienced a small effect (d = 0.24).

The two outcomes produced average gains as shown in Figure 1. The pattern suggests that learning in a blended mode has resulted in better enhancements in both math achievement and self-study skills. The difference in performance was particularly significant, with the experimental group gaining on average a score of 19.55 points greater than the control group's score. The experimental group's mean gain on self-study skills exceeded that of the control group by 0.89 scale points. Therefore, according to the description above, the cognitive and learner-autonomy results were well-substantial due to the blended learning model.

Figure 1: *Mean Gains in Mathematics Achievement and Self-Study Skills by Instructional Group*



Hypothesis Testing

Test of Homogeneity

Before conducting ANCOVA, independent-samples t-tests were conducted on the pre-test scores to determine whether the experimental and control groups were statistically equivalent at baseline. This was necessary because ANCOVA assumes that groups are reasonably comparable before the treatment, with the pre-test serving as the covariate. The result is presented in table 2.

Table 2: Independent-Samples t-Test for Pre-test Equivalence of Experimental and Control Groups

Variable	Group	*N*	Mean	SD	*T*	df	*p*	Cohen's *d*	Decision
Mathematics Achievement	Experimental	48	61.25	7.82	0.17	93	.865	0.03	Not significant
	Control	47	60.98	7.65					
Self-Study Skills	Experimental	48	3.12	0.68	0.28	93	.780	0.06	Not significant
	Control	47	3.08	0.71					

The results in Table 2 show that there was no statistically significant difference between the experimental and control groups in Mathematics Achievement pretest scores, t(93) = 0.17, p = .865. Similarly, there was no statistically significant difference between the groups in Self-Study Skills pretest scores, t(93) = 0.28, p = .780. The effect sizes were very small for both Mathematics Achievement, Cohen's d = 0.03, and Self-Study Skills, Cohen's d = 0.06.

This indicates that the two groups were statistically comparable before the intervention. Therefore, any posttest differences observed after the intervention can more reasonably be attributed to the instructional treatment rather than initial group differences.

Hypothesis 1: There is no significant difference in pretest and post-test mathematics achievement scores of students taught mathematics using blended learning models and those taught using traditional methods, after controlling for pre-test scores.

The post-test score of the students were compared using the pre-test as covariate.

Table 3: *ANCOVA Summary for Posttest Mathematics Achievement by Instructional Group*

Source	SS	Df	MS	F	P	Partial η^2
Pretest (covariate)	14,567.20	1	14,567.20	178.34	< .001	.660
Group (treatment)	8,924.10	1	8,924.10	112.45	< .001	.550
Error	7,301.80	92	79.40	—	—	—
Total	30,893.10	94	—	—	—	—

The ANCOVA result in Table 3 indicated that there was a significant treatment effect, F(1, 92) = 112.45, p < .001, partial η^2 = .550. The significant effect of the pretest covariate, F(1, 92) = 178.34, p < .001, partial η^2 = .660 suggests students' prior achievement was strongly related to posttest. Nonetheless, after controlling for pretest scores, group membership continued to be a significant predictor of mathematics achievement. As a result, we rejected the null hypothesis.

Hypothesis 2: There is no significant difference in pretest and posttest self-study skills scores of students in the experimental and control groups.

The difference in self-study skill improvement of the different groups was tested for significance using analysis of covariance. The result of the analysis is as shown in Table 3.

Table 4: *ANCOVA Summary for Self-Study Skills by Instructional Group*

Source	SS	Df	MS	F	P	Partial η^2
Pretest (covariate)	28.45	1	28.45	112.67	< .001	.551
Group (treatment)	17.82	1	17.82	68.32	< .001	.426
Error	24.01	92	0.26	—	—	—
Total	70.28	94	—	—	—	—

The ANCOVA result showed that pretest Self-Study Skills was a significant covariate, $F(1, 92) = 112.67$, $p < .001$, partial $\eta^2 = .551$. This implies that students' initial level of self-study skills significantly influenced their posttest self-study skills scores.

After adjusting for pretest Self-Study Skills, the effect of group was statistically significant, $F(1, 92) = 68.32$, $p < .001$, partial $\eta^2 = .426$. This indicates that students exposed to the blended learning model demonstrated significantly higher self-study skills than those taught through conventional classroom instruction. The effect size was large, showing that the treatment made a meaningful contribution to the development of students' self-directed learning behaviours. Therefore, the null hypothesis stating that there is no significant difference in pretest and posttest self-study skills scores of students in the experimental and control groups was rejected.

Discussion of Finding

The findings of this study indicate that the rotation-based blended learning model produced substantial improvement in students' mathematics achievement and self-study skills when compared with conventional classroom instruction. This conclusion is supported by the convergence between the descriptive results and the inferential results: the experimental group recorded higher mean gains, while the ANCOVA results confirmed statistically significant treatment effects after controlling for pretest scores. Thus, the observed improvement cannot be explained merely by initial differences between the groups; rather, it suggests that the instructional model made a meaningful contribution to students' learning outcomes.

The positive effect of blended learning on mathematics achievement is consistent with the wider literature on blended and hybrid learning. Hrastinski (2019) argues that blended learning should not be reduced to the simple addition of technology to classroom teaching, but should be understood as a deliberate integration of online and face-to-face experiences. The present finding supports this position because the intervention did not replace the teacher; rather, it reorganized learning so that students could benefit from teacher explanation, guided classroom support, digital practice, and independent revision. This may explain why students in the experimental group achieved higher posttest scores than those exposed to conventional instruction alone.

The result also agrees with Tong et al. (2022), who found that a flex model of blended learning improved students' mathematics achievement, self-study skills, and learning attitudes. The similarity between Tong et al.'s findings and the present study may be due to the shared emphasis on structured digital engagement, teacher support, and opportunities for students to revisit learning materials outside the normal pace of classroom teaching. In both studies, blended learning appears to have worked not because technology was present, but because technology expanded opportunities for practice, feedback, and learner control.

The findings further corroborate Egara and Mosimege (2024), who reported that secondary school students taught mathematics through blended learning achieved and retained better than those taught through conventional methods. Their Nigerian secondary school context makes the comparison especially relevant. The consistency between their findings and the present study suggests that blended learning can be effective in mathematics classrooms within developing educational contexts when the model is structured, curriculum-aligned, and supported by teacher mediation. However, this agreement should be interpreted carefully. Egara and Mosimege's intervention lasted four weeks, while the present study used a longer intervention period; therefore, the larger gains in the present study may partly reflect greater exposure time, repeated practice, and stronger consolidation of mathematical concepts.

At the meta-analytic level, the result is also consistent with Vo et al. (2017), who found

that blended learning had a positive effect on students' academic performance, particularly in STEM-related disciplines. Similarly, Setiawan et al. (2022) reported a positive effect of blended learning on students' mathematical ability. However, the magnitude of improvement in the present study appears stronger than the average effects reported in some meta-analyses. This difference may be explained by contextual and methodological factors, including the relatively focused subject area, the use of intact classes, the close alignment between intervention activities and the achievement test, and the possibility that students in the experimental group received more frequent opportunities for guided practice and corrective feedback.

Nevertheless, not all previous studies have reported strong or uniform effects of blended learning. Some studies have found mixed or non-significant differences between bl ended and traditional learning environments, especially where students were already high-achieving or where the online component was largely self-paced with limited teacher scaffolding. Balentyne and Varga (2017), for example, noted that evidence on blended learning has been mixed and that some high-ability mathematics students did not show significant achievement differences between traditional and self-paced blended courses. This contradiction may be due to ceiling effects among high-performing students, weaker dependence on teacher-mediated support, or insufficient differentiation between the blended and conventional learning conditions. In contrast, the present study appears to have provided a more structured rotation model, which may have benefited students who needed repeated exposure, feedback, and guided independent practice.

The study also found significant improvement in self-study skills of the students. Blended learning requires students to manage learning time, revisit instructional materials, complete tasks independently, and monitor their progress. The significant improvement recorded by the experimental group therefore suggests that the intervention did not only improve mathematics achievement but also strengthened students' capacity for self-regulated learning. This agrees with Uz and Uzun (2018), who found that blended learning environments can enhance self-regulated and self-directed learning skills. It also aligns with recent evidence from Zhao et al. (2025), who found that self-regulated learning strategies such as organization, metacognition, time management, and effort regulation were significantly associated with academic performance in online and blended learning environments.

The connection between self-study skills and achievement is particularly important. The gain in mathematics achievement may not have resulted from exposure to digital content alone; rather, it may have been mediated by students' improved ability to study independently, practise repeatedly, monitor errors, and seek clarification when needed. This interpretation is supported by Guntur and Purnomo's (2024) meta-analysis, which found that self-regulated learning interventions had a moderate positive effect on learning outcomes in online and blended environments. Thus, the present study suggests that blended learning may be most effective when it simultaneously improves content mastery and the learning behaviours that support mastery.

The findings also have practical implications for mathematics teaching. The evidence suggests that blended learning should be treated as a pedagogical model rather than a technology project. The Education Endowment Foundation (2019) cautions that digital technology is more likely to improve learning when it enhances teaching quality, feedback, practice, and assessment. This is relevant to the present study because the rotation model appears to have created additional opportunities for explanation, practice, and remediation. Therefore, mathematics teachers should not adopt digital tools merely because they are available; they should select tools that support mathematical reasoning, worked examples, diagnosis of errors, feedback, and repeated problem-solving.

However, the positive findings should not be generalized without attention to equity and implementation conditions. UNESCO's 2023

Global Education Monitoring Report warns that although technology can expand learning opportunities, unequal access to devices, connectivity, and home learning support can deepen existing educational inequalities. In resource-constrained settings, blended learning may produce weaker or contradictory results if students lack access to devices, internet connectivity, electricity, or quiet study spaces. This may explain why some studies report smaller or inconsistent effects: the success of blended learning depends not only on instructional design but also on infrastructure, teacher readiness, learner support, and equitable access.

Overall, the findings of this study contribute to the growing evidence that blended learning can improve mathematics achievement and self-study skills when it is structured, teacher-supported, and aligned with curriculum objectives. The study also helps explain why contradictory findings exist in the literature. Blended learning tends to produce stronger effects where online and face-to-face components are meaningfully integrated, where students receive feedback and guidance, where the intervention lasts long enough for learning routines to develop, and where access barriers are minimized. Conversely, weaker or non-significant effects are more likely when blended learning is poorly structured, treated as independent self-paced learning, implemented with limited teacher support, or introduced in contexts where students do not have reliable access to digital learning resources.

Implications from the Findings.

Based on the findings of this study, it could be implied that the teacher may use blended learning as an effective instructional model for improving the learning outcome in mathematics in secondary schools. The rotation hybrid is especially useful because it allows students to alternate among teacher-led instruction, guided group work, and individualized practice with digital tools. A differentiated learning, immediacy of feedback, and opportunities for repeated practice-all features prized in math instruction-are supported by this structure.

The analysis also suggests that the blended learning process should be regarded as a pedagogic model and not a technology project. According to the Education Endowment Foundation (2019) digital technology is likely to improve learning when it improves the quality of teaching, feedback, practice, and assessment rather than when it replaces effective teaching. math teachers must strive to select digital tools that foster mathematical explanation, practice, diagnosis, and feedback rather than just available technologies.

Moreover, the robust improvement in self-study skills indicates that blended learning can effectively support the adoption of independent study habits among students, as long as the model is controlled and monitored. Blended mathematics offerings should therefore explicitly include teacher support for self-study and study routines, including goal-setting, tracking progress, taking reflective notes, timing study sessions, for example, and teacher feedback on independent work. Students may apply self-study skills outside the mathematics classroom and lesson.

The results are also essential for equity and implementation. UNESCO (2023) warned that education technology should be judged based on relevance, equity, scalability, sustainability. In resource-constrained settings, blended learning must not presume that all learners have consistent internet access, devices, and quiet home study spaces. To overcome barriers to equity, schools should offer supervised rotation stations, offline resources, device-sharing plans and teacher-mediated access to online resources. In absence of these supports, blended learning could exacerbate rather than mitigate learning inequalities.

Conclusion

This study examined the effect of a rotation-based blended learning model on mathematics achievement and self-study skills among secondary school students in Ekiti State, Nigeria. The findings showed that students exposed to the blended learning model achieved significantly higher posttest

mathematics scores and stronger self-study skills than students taught through conventional classroom instruction, after controlling for pretest scores. The results suggest that a structured blended learning approach can support both mathematical understanding and independent learning habits when it combines digital practice, teacher guidance, feedback, and monitored self-paced learning.

The study recommends the following;

1. that mathematics teachers and school administrators consider carefully planned blended learning models as part of efforts to improve secondary school mathematics instruction.
2. Implementation should be supported by teacher training, accessible digital resources, reliable classroom routines, and explicit attention to students' self-study skills.
3. Policymakers and curriculum planners should also consider how school-supported rotation models can be adapted for resource-constrained settings without widening digital inequalities.

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