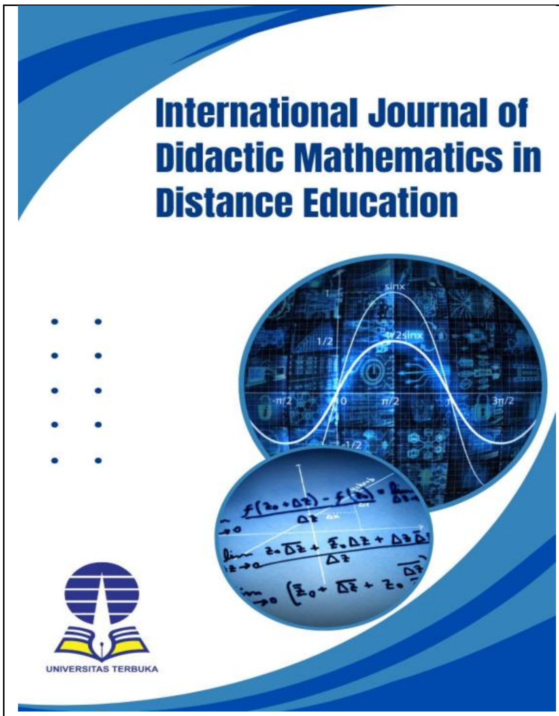
INTERNATIONAL JOURNAL OF
DIDACTIC MATHEMATICS IN DISTANCE EDUCATION

Journal homepage: https://jurnal.ut.ac.id/index.php/ijdmde



REACT instructional strategy and secondary school students' mathematics achievement: Gender inclusivity and implications for distance mathematics education

Akorede Ayoola Asanre[1], Oluwadayo Taiwo Abiodun[2], Gbenga Samuel Olusola[3], Xulu Ntuthuko

[1]Department of Mathematics, Science and Technology Education, University of Zululand, KwaZulu-Natal, South Africa, koredeayoola289@gmail.com

[2]Department of Mathematics Education, Tai Solarin Federal University of Education, Ogun State, Nigeria, abiodunto@tasued.edu.ng

[3]Department of Mathematics Education, Tai Solarin Federal University of Education, Ogun State, Nigeria, olusolags@tasued.edu.ng

[4]Department of Mathematics, Science and Technology Education, University of Zululand, KwaZulu-Natal, South Africa, NtuthukoN@unizulu.ac.za

To cite this article:
Asanre, A.A., Abiodun, O.T., Olusola, G.S., & Ntuthuko, X. (2026). REACT instructional strategy and secondary school students' mathematics achievement: Gender inclusivity and implications for distance mathematics education. *International Journal of Didactic Mathematics in Distance Education*, *3*(2), 137-160.

To link to this article:
https://jurnal.ut.ac.id/index.php/ijdmde

Published by:
Universitas Terbuka
Jl. Pd. Cabe Raya, Pd. Cabe Udik, Kec. Pamulang, Kota Tangerang Selatan, Banten 15437

International Journal of
Didactic Mathematics in Distance Education
https://jurnal.ut.ac.id/index.php/ijdmde
IJDMDE
LPPM UT
LEMBAGA PENELITIAN DAN PENGABDIAN KEPADA MASYARAKAT UNIVERSITAS TERBUKA

REACT instructional strategy and secondary school students' mathematics achievement: Gender inclusivity and implications for distance mathematics education

Akorede Ayoola Asanre[1]*, Oluwadayo Taiwo Abiodun[2], Gbenga Samuel Olusola[3], Xulu Ntuthuko[4]

[1]Department of Mathematics, Science and Technology Education, University of Zululand, KwaZulu-Natal, South Africa, koredeayoola289@gmail.com

[2]Department of Mathematics Education, Tai Solarin Federal University of Education, Ogun State, Nigeria, abiodunto@tasued.edu.ng

[3]Department of Mathematics Education, Tai Solarin Federal University of Education, Ogun State, Nigeria, olusolags@tasued.edu.ng

[4]Department of Mathematics, Science and Technology Education, University of Zululand, KwaZulu-Natal, South Africa, NtuthukoN@unizulu.ac.za

*Corresponding Author: abiodunto@tasued.edu.ng

Abstract

Persistent difficulties in mathematics achievement highlight the need for instructional approaches that connect abstract concepts with learners' experiences and promote active engagement. This study examined the effect of the Relating, Experiencing, Applying, Cooperating, and Transferring (REACT) instructional strategy on senior secondary school students' mathematics achievement, considering gender and implications for distance mathematics education. A pretest–posttest quasi-experimental design with a control group involved 80 Senior Secondary School II students from two purposively selected schools in Ijebu-Ode, Ogun State, Nigeria. The experimental group received REACT-based instruction, while the control group received conventional instruction. Data were collected using a 25-item Mathematics Achievement Test with a reliability coefficient of 0.88 and analyzed using descriptive statistics and analysis of covariance (ANCOVA). Results showed that students exposed to REACT achieved higher post-test scores than those taught conventionally, with instructional strategy significantly affecting mathematics achievement. Gender had no significant effect, and no significant interaction between instructional strategy and gender was found, indicating comparable outcomes for male and female students. The findings support REACT as an inclusive, constructivist-oriented approach and provide a pedagogical basis for adapting its contextual, collaborative, experiential, and transfer-oriented principles to blended and distance mathematics learning environments in future studies.

Article History

Received: March 19, 2026

Revised: May 9, 2026

Accepted: June 10, 2026

Published Online: August 27, 2026

Keywords:

Constructivist Learning; Distance Mathematics Education; Gender Inclusivity; Mathematics Achievement; REACT Instructional Strategy

International Journal of
Didactic Mathematics in Distance Education
https://jurnal.ut.ac.id/index.php/ijdmde

1. Introduction

Mathematics is therefore seen as a broad and complex area of research that entails the investigation, understanding, and application of measurements, values, forms, patterns, and structures. It is both theoretical and practical discipline, with a wide range of branches and applications. Agormor et al. (2022) submitted that our daily lives are fundamentally impacted by mathematics, which is present in everything around us. Therefore, mathematics has a major role in the social, economic, everyday, scientific, and technological advancement of nations. Both authors stressed the major aspect in which mathematics is applicable, regarded it as one of the oldest academic disciplines in human history and one of the most fundamental aspects of human intellect.

Mathematics has been seen as an entity that is about problem solving; it should therefore be taught and learned with seriousness (Akinoso, 2015). The researcher went on to say that mathematics is helpful in the following areas: record-keeping tasks including addition, subtraction, division, and multiplication of numbers, money, length, mass, and time; occupations like plumbing, carpentry, and tailoring which require a foundational understanding of geometry, including measurement, angle, symmetry, and plane shapes. Other courses like physics, geography, accountancy, and economics also benefit from mathematics. In the view of Asanre et al. (2025), They pointed out that the significance of mathematics cannot be emphasized because it affects areas that are related to mathematics and permeates practically all academic fields, whether or not they are mathematical. In an era characterized by rapid technological progress, proficiency in mathematics is no longer optional but essential for learners aspiring to thrive in fields such as engineering, medicine, finance, and data science. Authors like Agormor et al. (2022) submits that poor performance in mathematics has become a persistent issue that can keep developing nations from reaching their targets for development. This is echoed by Asanre et al. (2024a), who reported that there is a worrying pattern of student academic performance in mathematics falling over time, underscoring the necessity of giving students' success in mathematics education top priority.

Poor performance in mathematics is often attributed to several factors, including lack of interest, ineffective teaching methods, and the failure to connect mathematical concepts to real-life situations. This is stressed by the submission of Asanre et al. (2024a) that a fraction of secondary school learners usually pass local and external mathematics exams at the credit level or higher, indicating a significant fall in academic achievement over time. More so, exams or continuous assessment techniques are commonly used to evaluate the academic achievement of learners, and there is continuing discussion regarding the best testing strategies.

Many social divide factors are responsible for learners' underperformance at the secondary school level, including gender disparity, access to resources, quality of education, and cultural and linguistic differences. Addressing social divides and promoting equity in education requires systemic efforts to reduce disparities in resources, opportunities and support systems (Iroko et al., 2024). They stressed that gender stereotyping pervades the educational system from elementary to tertiary levels and manifests itself in a variety of ways. Reiterating this idea, Asanre et al. (2024b) advocate the need for improved teaching methods and a stronger focus on learner-centered methods of teaching and learning mathematics in order to strengthen the achievement of learners in the subject. They explained that to facilitate the process of knowledge transfer, teachers must employ efficient teaching techniques that are suitable for a particular purpose and their intended outcomes.

Majid et al. (2024) asserted that having the ability to display different teaching strategies and tactics within the subject constitutes one of the mathematics teacher's talents. REACT model has been identified as a strategy that could enhance students' achievement. They stressed that REACT strategy is a method of contextual learning that is based on the core ideas of constructivism. Students must participate in ongoing activities in order to develop and apply knowledge in science education. Boateng et al. (2023) reported that quite a few constructivist teaching methods exist, but numerous studies have demonstrated the effectiveness of the REACT method in helping students better understand challenging scientific subjects. These five components are explained by Majid et al. (2024), Relating implies relationships with past knowledge that learners already have and comprehend. Secondly, experiencing emphasizes investigation, learning, and the development of novel mathematical ideas. Thirdly, applying the ideas they have learned in the past. Cooperating is the educational process that facilitates students' comprehension of the subject matter and strengthens contextual learning by encouraging student cooperation and communication. Lastly, transferring entails using what learners have learned in new settings or contexts that weren't covered in class.

Involving students in the learning process makes the strategy cultivate curiosity, deepens conceptual understanding, and fosters a sense of ownership over their learning outcomes (Majid et al., 2024; Nurzannah et al., 2021; Latri and Agusalim, 2020). The pedagogical characteristics of REACT may also be relevant beyond conventional face-to-face mathematics classrooms, particularly in blended and distance learning environments. Distance mathematics education requires more than simply providing learners with digital access to mathematical content; it also requires instructional designs that sustain meaningful engagement, interaction, contextual understanding, and opportunities to apply mathematical knowledge with greater learner independence. In this regard, the five components of REACT offer a potentially useful pedagogical structure. Relating can connect mathematical ideas with learners' prior knowledge and everyday experiences, Experiencing can promote active exploration of mathematical concepts, and Applying can situate learning within authentic problems. Similarly, Cooperating can support peer interaction and collaborative mathematical reasoning, while Transferring encourages learners to extend their understanding to unfamiliar situations. These characteristics suggest that REACT may provide pedagogical principles that are transferable to flexible and distance mathematics learning contexts, although empirical evidence regarding its effectiveness in such environments remains limited.

Despite the promising evidence on REACT, important gaps remain in the literature. Most existing studies examining REACT in mathematics education have been conducted in Indonesian and other Southeast Asian contexts, while evidence from Nigerian secondary schools remains limited. Moreover, relatively little attention has been given to whether the effectiveness of REACT varies according to gender, an important consideration for equitable mathematics education. Beyond these empirical gaps, the pedagogical implications of REACT for flexible and distance mathematics learning remain underexplored. Its emphasis on contextualization, active experience, application, collaboration, and knowledge transfer appears compatible with instructional demands in learning environments where students may have reduced direct interaction with teachers. However, such potential should not be assumed from face-to-face evidence alone. Therefore, the present study examines the effect of REACT on secondary school students' mathematics achievement and the moderating role of gender in a Nigerian face-to-face context, while considering how the resulting pedagogical evidence may inform the future adaptation of REACT for distance mathematics education.

The main objective of the study is to examine the effect of REACT strategy on academic achievement of senior secondary school students in mathematics. Gender is considered as moderating variable. The following are specific objectives:

a) To determine the effect of REACT strategies on students' academic achievement in mathematics.
b) To examine the influence of gender on students' academic achievement in mathematics.
c) To examine the two-way interaction effect of strategies and gender on the academic achievement of secondary school students in mathematics.

1.1.1 Research Questions

This study seeks to answer the following research questions:

a) What is the achievement mean score of students taught using REACT and conventional strategies?
b) What is the achievement mean score of male and female students taught using the strategies?

1.1.2. Hypotheses

The study will test the following null hypotheses:

H_{01}: There is no significant effect of strategies on senior secondary school students' academic achievement in mathematics.

H_{02}: There is no significant influence of gender on senior secondary school students' academic achievement in mathematics.

H_{03}: There is no significant interaction effect of strategies and gender on senior secondary school students' academic achievement in mathematics.

1.2. Literature Review

1.2.1. Mathematics Achievement in Secondary Schools

In secondary education, mathematics achievement is a critical indicator of students' academic success and future opportunities in STEM fields. Fisher et al. (2015) stated that academic achievement occurs when students acquire knowledge of the academic material assigned to them by the school and that instructors usually need to do more than simply assess students' knowledge in an abstract way in order to ascertain whether or not students are mastering this academic content. Academic success is the level of proficiency or skill attained in school-related activities. It is often assessed using grades or units that come from a large sample of learners' performance on standardized tests. More so, Asanre et al. (2025) submitted that although there is considerable consensus regarding the optimum testing method for accessing students in Mathematics, hence achievement is frequently assessed through examinations or continuous evaluation. Ngozi and Solomon (2021), Achievement assessments are designed to evaluate a student's mastery or comprehension of general or specific topics to which he has been exposed. Over the years, there has been a loud clamor that secondary school's students' academic achievement has sharply declined. Less than half of the total number of students who sign up to take the tests typically pass the local and external examinations in Mathematics at or above the credit level (Asanre, 2019). Academic achievement in mathematics is influenced by various factors, including teaching methods, student motivation, encompassing individual characteristics and the availability of learning resources.

1.2.2. Gender Issues in the Learning of Mathematics in Secondary School

The underrepresentation of females in STEM fields has been a long-standing concern, with mathematics being a critical gateway subject. Various factors influence students' engagement and achievement in mathematics, including societal expectations, classroom experiences, teaching strategies, and cognitive differences. Additionally, Mashuri & Yawan (2023) argued that gender stereotypes contribute to the belief that mathematics is a male-dominated subject, leading to anxiety and lower confidence among female students. In contrast, boys tend to exhibit higher self-efficacy, which boosts their performance. Alam et al. (2022) also contributed that male students exhibited higher levels of self-efficacy and confidence when solving mathematical problems, whereas female students displayed greater anxiety, which negatively impacted their performance. Also, Diwa et al. (2023) also found that male teachers in Nigeria were more likely to believe in the superior mathematical abilities of male students, leading to unequal treatment in classroom interactions and assessments. This bias negatively affects female students' self-efficacy, contributing to the underrepresentation of girls in advanced mathematics courses and STEM careers. Researchers such as Asanre et al. (2024b), argued that there exists no significant gap between the gender in performance in mathematics, which suggests that gender had little impact on the performance of learners in mathematics. This contradiction with earlier researchers creates the necessity to check whether gender does affect the academic achievement of the students in mathematics.

1.2.3. Concept of REACT Strategy

The academic achievement of students is greatly influenced by the teaching approach a teacher uses in the classroom, student-centered constructivist teaching practices are said to boost student performance (Boateng et al., 2023). This submission was also aired by Latri and Agusalim (2020), they submitted that theoretically, using a range of learning techniques in the classroom increases students' chances of succeeding in the learning process. Majid et al. (2024) asserted that demonstrating a variety of teaching strategies and tactics within the subject is one of a math teacher's strengths. They emphasized that the REACT approach makes learning more meaningful and pleasurable by presenting educational content through circumstances that are pertinent to students' lives. Latri and Agusalim (2020) opined that one type of alternative learning that calls for students' active participation is the REACT learning approach. Majid et al. (2024) opined that REACT strategy is a method of contextual learning based on the core ideas of constructivism.

It entails ongoing student participation to develop and apply knowledge in science education. Nurzannah et al. (2021) reported that the term REACT stands for Relating, Experiencing, Applying, Cooperating, and Transferring. The REACT approach to learning is a development of contextual learning that focuses on students locating the concepts they are learning, working in small groups, applying these concepts in real-world situations, and transferring the concepts they have learned into new contexts. Majid et al. (2024) submitted that mathematics instruction using this REACT strategy incorporates five components: Relating isis the learning process which involves relationships with past knowledge that learners already have and comprehend, including abilities, aptitudes, passions, and exposure to instructional material with the help of the mathematics teacher.

The goal is for learners to understand the mathematical ideas being taught and use those ideas to solve mathematical puzzles. Secondly, experiencing emphasizes investigation, learning, and the development of novel mathematical ideas. To help with this process, students are encouraged to explore a variety of material and educational tools. Thirdly, students tackle current mathematics issues by applying the ideas they have learned in the past. Where instructors offer practical and pertinent exercises that highlight the use of mathematics in daily life. Also, cooperating is the educational process that facilitates students' comprehension of the subject matter and strengthens contextual learning by encouraging student cooperation and communication. Instructors assist students in cooperating to accomplish the intended results. Lastly, transferring entails using what learners have learned in new settings or contexts that weren't covered in class. Presentations of results from student conversations may be included, enabling students to exchange mathematical knowledge and cooperatively produce new insights.

1.3. Theoretical Framework

Constructivist learning theory forms the foundation of modern educational approaches like the REACT teaching strategy. This theory is influenced by the works of Jean Piaget and Lev Vygotsky, who focuses on key elements such as active engagement, collaboration with peers, and reflection on experiences, which reflected on the REACT strategy by emphasising that learning is an active and dynamic process through relating, experiencing, applying, cooperating, and transferring knowledge. Additionally, learners build new knowledge by connecting it to what they already know, rather than passively absorbing information (Xu and Shi, 2018). Ugwuozor (2020) found that students exposed to constructivist-based pedagogy significantly outperformed those taught using traditional methods. Active learning in these contexts encourages students to interact deeply with the material, fostering both understanding and retention. Hence, constructivism gives room for learners to build their knowledge through experiences and interactions instead of passively taking information which strongly aligns with the principles of REACT strategy. By laying emphasis on relating, experiencing, applying, cooperating, and transferring, giving room for student's hands-on activities, real world application of mathematics concepts, and collaborative learning. All these are essential for knowledge construction that is acknowledged by constructivism principles.

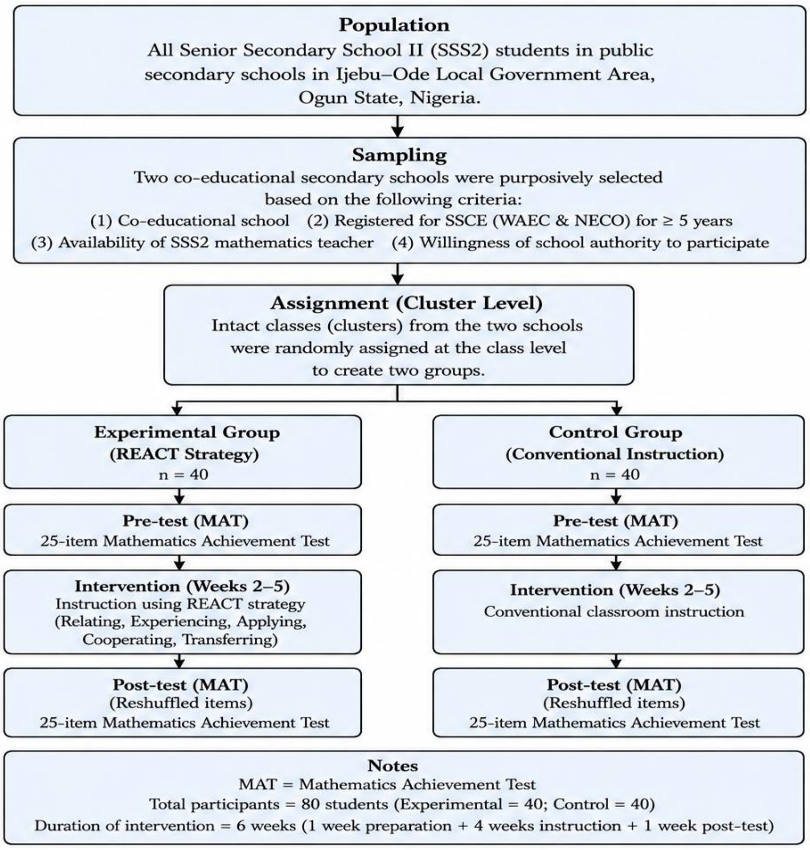
2. Methods

2.1 Research Design

This study employed a pretest–posttest quasi-experimental design with an experimental group and a control group to investigate the effect of the REACT instructional strategy on senior secondary school students' mathematics achievement. As illustrated in Figure 1, the design involved the selection of intact classes, their assignment to experimental and control conditions, the administration of a pretest, the implementation of different instructional strategies, and the administration of a post-test. The experimental group received mathematics instruction using the REACT strategy, whereas the control group was taught through conventional classroom instruction. The quasi-experimental design was considered appropriate because the study was conducted within existing school settings, where intact classes were maintained rather than randomly assigning individual students to experimental conditions.

As further shown in Figure 1, the two groups followed parallel pretest–intervention–post-test procedures. Both groups initially completed the Mathematics Achievement Test (MAT) to establish their baseline mathematics achievement. During the intervention period, the experimental group engaged in instructional activities structured around the five components of REACT while the control group continued with conventional mathematics instruction. At the end of the intervention, both groups completed the post-test to assess their mathematics achievement. Gender was incorporated as a moderating variable to determine whether mathematics achievement differed between male and female students and whether the effect of instructional strategy on achievement varied according to gender. Figure 1 provides an overview of the complete research design and the sequence of procedures followed in the study.

Figure 1
Quasi-Experimental Research Design of the Study



2.2 Participants

The population of the study comprised Senior Secondary School II (SSS2) students enrolled in public secondary schools in Ijebu-Ode Local Government Area, Ogun State, Nigeria. A total of 80 SSS2 students from two schools participated in the study. The schools were purposively selected based on four eligibility criteria: they were co-educational secondary schools, had registered students for the Senior School Certificate Examination (SSCE) administered by WAEC and NECO for at least five years, had mathematics teachers responsible for teaching SSS2 students, and had school authorities willing to permit the implementation of the intervention. Following school selection, intact classes were assigned to the experimental and control conditions at the class level rather than at the individual student level.

SSS2 students were considered appropriate participants because they had already been exposed to fundamental mathematical concepts and procedures required for solving algebraic problems addressed in the study. Their selection also minimized potential disruption associated with external examinations because they were not taking their final SSCE during the period of data collection. At the same time, they were approaching the stage of preparation for the SSCE in the following academic session, making mathematics achievement particularly relevant to their academic progression. Their existing mathematical background and position within the senior secondary school curriculum therefore provided an appropriate context for examining the effectiveness of the REACT instructional strategy.

2.3 Data Collection

Data were collected using the MAT, a 25-item multiple-choice test designed to measure students' mathematics achievement. Each item consisted of four response options, including one correct answer and three distractors. The items were adapted from previous Senior School Certificate Examination questions administered between 2018 and 2022 and covered the cognitive domains of knowledge, comprehension, and application. The content and face validity of the research instruments, including the REACT instructional package, were evaluated by two experts from the Department of Mathematics, Tai Solarin University of Education, Ijagun, Ogun State, and two experienced senior secondary school mathematics teachers. Their comments and recommendations were incorporated into the final versions of the instruments. The MAT was pilot-tested with 25 students outside the study population, and its internal consistency was examined using the split-half method. The two sets of scores were correlated using Pearson Product-Moment Correlation, followed by the Spearman-Brown prophecy formula, resulting in a reliability coefficient of 0.88.

Data collection was conducted over six weeks. During the first week, the mathematics teacher responsible for the experimental group was introduced to the REACT instructional package and its implementation procedures, and the MAT was administered as a pretest to both the experimental and control groups to establish baseline achievement. During Weeks 2-5, students in the experimental group received mathematics instruction using activities based on the five REACT components, whereas students in the control group continued to receive conventional classroom instruction. In the sixth and final week, the MAT items were rearranged and administered to both groups as a post-test. Using the same achievement measure with rearranged item ordering enabled the researchers to compare students' achievement before and after the intervention while reducing the possibility that students simply recalled the sequence of responses from the pretest.

2.4 Data Analysis

The data obtained from the pretest and post-test administrations were analyzed using both descriptive and inferential statistics. Mean scores and standard deviations were calculated to describe students' mathematics achievement across the experimental and control groups and according to gender. These descriptive statistics were used to address the research questions by showing patterns of achievement before and after the intervention and providing an initial comparison of the performance of students exposed to the REACT strategy and those receiving conventional instruction.

Analysis of covariance (ANCOVA) was subsequently employed to test the study hypotheses and determine the effect of instructional strategy, gender, and the interaction between instructional strategy and gender on students' post-test mathematics achievement. Students' pretest achievement scores were included as a covariate to statistically adjust for initial differences in mathematics achievement between the groups.

Before conducting ANCOVA, the assumptions of homogeneity of variance and homogeneity of regression slopes were examined and found to be satisfied, supporting the appropriateness of the analysis for the dataset. The ANCOVA therefore provided an adjusted assessment of the effect of the instructional strategy on post-intervention mathematics achievement while accounting for students' baseline achievement.

2.5 Ethical Clearance

Ethical principles governing educational research were observed throughout the study. Before data collection commenced, a letter of introduction was obtained from the researchers' department and presented to the participating schools to formally introduce the researchers and explain the purpose of the study. Permission to conduct the research was subsequently obtained from the relevant school authorities. Informed consent was also obtained from the school administrators, participating teachers, and students before their involvement in the study. Participation was voluntary, and participants were informed about the research procedures and their involvement in the study.

The confidentiality and anonymity of all participants were maintained throughout data collection, analysis, and reporting. Participants were informed that they could withdraw from the study at any stage without repercussions, and their participation or withdrawal did not affect their regular academic activities or progress. The intervention was implemented within the existing mathematics instructional setting to minimize disruption to normal school activities, and no participant was intentionally exposed to physical, psychological, or academic harm. All information obtained from the participants was treated confidentially and used exclusively for the purposes of the study.

3. Results and Discussion

3.1 Results

3.1.1 Implementation of the REACT Instructional Strategy

Before examining the statistical effect of the intervention on mathematics achievement, the implementation of the REACT instructional strategy in the experimental group was described to show how the treatment was enacted in the classroom. The intervention was implemented during Weeks 2–5, following teacher preparation and pretesting in Week 1 and preceding post-testing in Week 6. Throughout the intervention, mathematics lessons were organized according to the five interconnected components of REACT: Relating, Experiencing, Applying, Cooperating, and Transferring. The stages were not treated as isolated classroom activities; rather, they formed a progressive learning sequence in which students moved from connecting mathematics with familiar experiences to exploring concepts, applying them, discussing them collaboratively, and finally using their understanding in new situations.

The implementation emphasized active student participation while the teacher functioned primarily as a facilitator of mathematical learning. Students were encouraged to express prior knowledge, investigate mathematical relationships, explain their reasoning, compare solution strategies with peers, and connect mathematical ideas with contextual problems. The descriptive implementation of each stage is presented below, while Figure 2 provides an illustrative representation of the types of student learning activities associated with the five REACT stages. The illustration is conceptual and is not a photograph of the study participants.

(a) Relating

The implementation began with the Relating stage, in which the teacher introduced the mathematical topic through situations that were familiar and meaningful to the students. Rather than beginning with formulas or procedural explanations, the teacher posed contextual questions and problems intended to activate students' existing knowledge and everyday experiences. Students were encouraged to describe what they already knew about the situation, identify mathematical information embedded in the context, and connect their responses with the concept to be learned. The teacher then used students' contributions as a bridge between informal understanding and formal mathematical ideas.

This stage created an entry point into the lesson and positioned students' prior experiences as resources for learning mathematics. Classroom interaction at this stage involved questioning, short discussions, sharing examples, and clarification of students' initial ideas. The purpose was not yet to obtain complete solutions, but to establish meaningful connections that could support subsequent exploration. In this way, Relating provided the contextual foundation for the remaining REACT stages.

(b) Experiencing

Following the contextual introduction, students moved to the Experiencing stage, where they explored the mathematical ideas through guided activities. The teacher provided tasks that required students to observe, represent, compare, calculate, and identify mathematical patterns or relationships. Students were encouraged to work through the tasks rather than simply reproduce a demonstrated procedure. When difficulties emerged, the teacher used prompts and guiding questions to support students without immediately providing the solution.

Through these activities, students had opportunities to construct meaning from the mathematical situations presented to them. Their responses, representations, and emerging conjectures were discussed and refined during the lesson. The Experiencing stage therefore shifted the learning process from listening to active exploration and allowed students to develop a more concrete basis for understanding the concepts before applying them to additional problems.

(c) Applying

In the Applying stage, students used the mathematical concepts developed during the earlier stages to solve related problems. The tasks included routine and contextual problems that required students to select appropriate procedures, perform calculations, and explain how their solutions were obtained. Students initially attempted the problems individually or in pairs, while the teacher provided scaffolding when necessary. Attention was given not only to obtaining correct answers but also to the reasoning and procedures used to reach them.

This stage provided an opportunity to determine whether students could use their emerging conceptual understanding in problem-solving situations. Students were asked to explain their solution processes and, where appropriate, compare alternative methods. The teacher clarified misconceptions and connected students' strategies with the underlying mathematical principles. Applying therefore served as a transition from exploration toward purposeful use of mathematical knowledge.

(d) Cooperating

During the Cooperating stage, students worked in small groups to discuss and solve mathematical tasks collaboratively. Group members shared ideas, compared procedures, questioned one another's reasoning, and attempted to reach a common solution. The teacher circulated among the groups, monitored participation, provided prompts when groups encountered difficulties, and encouraged students to justify their mathematical decisions rather than relying only on an answer supplied by another group member.

The collaborative structure allowed students to articulate mathematical thinking and encounter different ways of approaching the same problem. Students could clarify their own understanding by explaining ideas to peers and could reconsider their strategies after hearing alternative reasoning. Cooperation was therefore used as a learning mechanism rather than merely as a seating arrangement, with mathematical dialogue and shared problem solving forming the central activities of this stage.

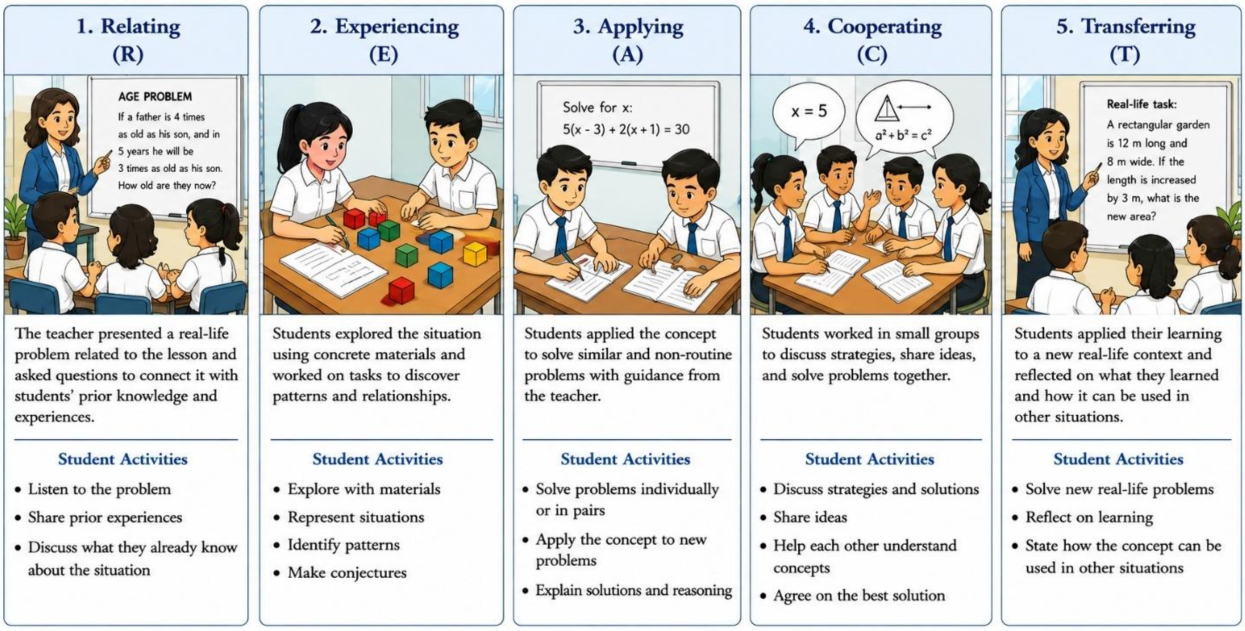
(e) Transferring

The final stage was Transferring, in which students were challenged to use the mathematical knowledge and strategies developed during the preceding stages in unfamiliar or modified situations. The teacher introduced new problems or real-life contexts that differed from the examples previously discussed. Students were expected to identify relevant mathematical ideas independently, determine an appropriate strategy, and explain how prior learning could be adapted to the new situation.

At this stage, students also reflected on what they had learned and how the mathematical concept could be useful beyond the original classroom task. The teacher concluded the learning sequence by discussing students' solutions, highlighting connections across the five REACT stages, and addressing remaining misconceptions. Transferring thus provided an opportunity to examine whether learning extended beyond immediate practice and whether students could mobilize their mathematical understanding in new contexts.

Across the intervention, the five stages created a structured progression from contextual activation to increasingly independent use of mathematical knowledge. Relating activated prior knowledge, Experiencing supported exploration, Applying provided opportunities for problem solving, Cooperating strengthened mathematical interaction, and Transferring extended learning to new situations. This sequence was intended to maintain the constructivist orientation of REACT by positioning students as active participants in meaning making while the teacher provided guidance and scaffolding throughout the learning process.

Figure 2
Illustrative Representation of Student Activities across the Five REACT Instructional Stages



3.2 Effects of the REACT Instructional Strategy on Mathematics Achievement

This section presents the quantitative findings of the study in relation to the research questions and hypotheses formulated to examine the effects of the REACT instructional strategy on students' mathematics achievement. The analysis focuses on differences in achievement between students exposed to the REACT and conventional instructional strategies, as well as the effects of gender and its interaction with instructional strategy. To address the first research question—what are the mean achievement scores of students taught using the REACT instructional strategy and those taught using the conventional instructional strategy—descriptive statistics were used to compare the pretest and post-test achievement scores of the two groups. The corresponding mean scores and standard deviations are presented in Table 1.

Table 1
Mean Achievement Scores and Standard Deviation of students who were taught using REACT and conventional strategies

Groups		Pre-Test	Post-test
	N	40	40
REACT	Mean	10.28	17.30
	S. D	1.845	2.145
	N	40	40
Control	Mean	11.73	12.16
	S. D	2.534	2.102

Table 1 shows that students that are exposed to REACT strategy had a post-test mean achievement score of 17.30 while students in control group had a post-test Mean achievement score of 12.16 respectively. Indicating the strength of the strategy over the conventional approach.

The second research question examined students' mathematics achievement according to gender across the instructional strategies. Specifically, it sought to determine whether male and female students demonstrated differences in their achievement after being exposed to the REACT and conventional instructional strategies. To address this research question, the mean achievement scores and standard deviations of male and female students were compared across the two instructional groups. The descriptive results of this comparison are presented in Table 2.

Table 2

Mean achievement Scores and Standard Deviation of Male and Female students who were exposed to REACT and Control Strategies

Groups	Sex		Pre-Test	Post-test
		N	17	17
	Male	Mean	11.05	17.00
		S.D	2.339	2.280
REACT	Female	N	23	23
		Mean	10.87	16.93
		S.D	1.843	2.972
	Total	N	40	40
		N	17	17
	Male	Mean	10.65	11.87
Control		S.D	2.347	1.902
	Female	N	23	23
		Mean	10.34	11.89
		S.D	2.341	3.043
	Total	N	40	40

Table 2 shows that Male students in REACT method of teaching had a post-mean of 17.00 while female students had a post-mean achievement score of 16.93 which is not significantly different. While male students in the Control Group, had a post-mean 11.87 and female students had a post-mean achievement of 11.89 respectively. Showing no difference as compared to the experimental group.

Following the descriptive analysis of students' mathematics achievement, inferential analysis was conducted to determine whether the observed differences were statistically significant. ANCOVA was employed to examine the main effects of instructional strategy and gender, as well as the interaction effect between instructional strategy and gender on students' post-test mathematics achievement, while controlling for their pretest scores. This analysis provides the basis for testing the three hypotheses formulated in the study. The results of the ANCOVA are presented in Table 3.

Table 3
Summary of Analysis of Covariance of Students' Achievement in Mathematics According to Strategy and Gender

Dependent Variable: Achievement

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	519.641[a]	16	32.478	.735	.749
Intercept	4978.058	1	4978.058	112.603	.000
Pre_test	14.850	1	14.850	.336	.564
Strategy	1.989	1	1.989	.645	.003
Gender	31.463	1	31.463	.712	.402
strategy * gender	23.611	1	23.611	.534	.468
Error	2785.159	63	44.209		
Total	88848.000	80			
Corrected Total	3304.800	79			

a. R Squared = .157 (Adjusted R Squared = -.057)

The result presented in Table 3 indicates that the instructional strategies had a significant effect on senior secondary school students' academic achievement in mathematics. The analysis revealed a statistically significant difference in the post-test mean achievement scores of students exposed to the two instructional strategies, as indicated by the reported F-value, $F(1, 79) = 0.645$, $p < 0.05$. This finding suggests that students' mathematics achievement differed depending on the instructional strategy to which they were exposed. In other words, the type of instructional strategy employed in the teaching and learning process contributed significantly to the variation observed in students' post-test achievement scores.

Based on this result, the null hypothesis stating that there is no significant effect of instructional strategies on senior secondary school students' academic achievement in mathematics is rejected. It can therefore be concluded that instructional strategies significantly influence students' academic achievement in mathematics. This finding highlights the importance of selecting and implementing appropriate instructional strategies in mathematics classrooms, as different approaches to instruction may produce different levels of student achievement. Thus, teachers should carefully consider the instructional strategies they employ to create learning experiences that can effectively support and improve students' understanding and performance in mathematics.

While the previous analysis demonstrated a significant effect of instructional strategies on students' mathematics achievement, the subsequent analysis examined whether gender also contributed to differences in students' achievement. The result presented in Table 3 shows that gender had no significant effect on senior secondary school students' academic achievement in mathematics, as indicated by $F(1, 79) = 0.712$, $p > 0.05$. This finding indicates that the achievement scores of male and female students did not differ significantly after being exposed to the two instructional strategies used in the study. In other words, both male and female students demonstrated relatively similar levels of achievement in mathematics regardless of their gender. Therefore, the null hypothesis stating that there is no significant effect of gender on senior secondary school students' academic achievement in mathematics is retained. It can thus be concluded that gender does not significantly influence students' mathematics achievement, suggesting that male and female students have comparable opportunities to achieve similar learning outcomes when exposed to the instructional strategies employed in this study.

Following the finding that gender did not significantly influence students' mathematics achievement, further analysis was conducted to determine whether the effectiveness of the instructional strategies differed according to students' gender. The result presented in Table 3 shows that there was no significant interaction effect between instructional strategies and gender on senior secondary school students' academic achievement in mathematics, as indicated by $F(1, 79) = 0.534$, $p > 0.05$. This finding suggests that the effects of the instructional strategies on students' mathematics achievement were relatively consistent across male and female students. In other words, the differences in achievement associated with the instructional strategies did not depend significantly on students' gender. Therefore, the null hypothesis stating that there is no significant interaction effect of instructional strategies and gender on senior secondary school students' academic achievement in mathematics is retained. It can thus be concluded that gender does not significantly moderate the effect of the instructional strategies on students' mathematics achievement.

3.2 Discussion

The findings of this study indicate that students exposed to the REACT strategy achieved higher post-test scores than those taught through conventional instruction, confirming the effectiveness of the strategy relative to traditional pedagogy. This corroborates the earlier submission of Nurzannah et al. (2021), Zulkarnain et al. (2021), and Musyadad and Avip (2020), who all established that REACT improves students' mathematical proficiency in secondary and high school settings. This pattern is further reinforced by more recent evidence: Sihite and Pangaribuan (2023) found that combining cooperative learning with REACT components strengthened students' mathematical problem-solving ability, while Quainoo et al. (2021) reported comparable achievement gains in a related science context, suggesting that the relating-experiencing-applying-cooperating-transferring sequence transfers well across content domains. Similarly, Juwita et al. (2024) demonstrated that REACT instruction supported by structured worksheets significantly improved students' problem-solving performance in senior secondary mathematics, reinforcing the pattern observed in the present study's post-test results. Elbehary (2024) further showed that systematic training in REACT strategies strengthened not only procedural but also conceptual understanding among learners, indicating that the strategy's benefit extends beyond short-term score gains toward more durable mathematical reasoning.

The result on Hypothesis One is consistent with the constructivist foundation of the REACT strategy. This is supported by Majid et al. (2024), who submitted that REACT is a method of contextual learning rooted in the core ideas of constructivism, requiring students to participate in ongoing activities to develop and apply knowledge. Boateng et al. (2023) similarly reported that although numerous constructivist teaching methods

International Journal of Didactic Mathematics in Distance Education
https://jurnal.ut.ac.id/index.php/ijdmde

exist, REACT has repeatedly demonstrated effectiveness in helping students better understand challenging subject matter. This theoretical premise is reinforced by more recent meta-analytic evidence: Origenes (2025) found a consistently positive effect of constructivist approaches on mathematics achievement across multiple studies, Akkoç and Ocak (2019) reported that constructivist learning environments produced measurably higher academic achievement than conventional instruction, and Çibukçiu (2025) added that constructivist methods particularly enhance students' problem-solving performance by encouraging active engagement rather than rote procedural practice. It should be noted, however, that the strength of this claim in the present study depends on the accuracy of the reported F and significance values in the ANCOVA output; any inconsistency in those statistics would necessitate a corresponding revision of this interpretation.

Beyond the direct effect of strategy, the present findings also point toward the value of the cooperative dimension embedded within REACT. Ismail et al. (2022) found that think-pair-share style cooperative techniques improved both participation and performance among secondary students, while Siller and Ahmad (2024), in a quasi-experimental design closely resembling the present study, demonstrated that collaborative learning significantly improved sixth-grade students' mathematics achievement regardless of initial ability level. Prieto-Saborit et al. (2022), in a longitudinal study, further showed that cooperative learning contributes not only to performance gains but also to more equitable outcomes across student subgroups, a finding directly relevant to the present study's examination of gender as a moderating variable.

Turning to the gender-related findings, the results showed no significant main effect of gender, thereby giving room for equity among learners and ensuring that both genders perform well in mathematics. This is supported by the work of Asanre et al. (2025), who reported that an effective educational strategy helps to reduce inequalities by establishing inclusive and active learning environments. Moreover, Iroko et al. (2024) argued that there exists no significant gap between genders in mathematics performance, supporting the outcome of the present finding. This pattern is also consistent with more recent literature suggesting that well-designed, student-centered instructional strategies can narrow gender disparities otherwise observed in traditional mathematics classrooms. Pena et al. (2021) argued that inclusive pedagogical approaches actively reduce gender-based participation gaps in STEM subjects, while Lee et al. (2021) demonstrated that interventions addressing mindset and stereotype threat directly diminish gender-based performance differences, implying that the gender-neutral outcome observed here may partly reflect the inclusive, activity-based nature of REACT.

At the same time, the broader gender and mathematics literature cautions against over-generalizing a single non-significant finding. Kaiser and Zhu (2022) and Arroyo-Barrigüete et al. (2023) both documented persistent gender gaps in mathematics achievement in other educational contexts, indicating that the absence of a gender effect in the present sample should not be interpreted as evidence that gender disparities in mathematics achievement have been resolved more broadly. Johnson et al. (2020)

similarly noted that gender inequities in mathematics classrooms often operate through subtler participation and interaction patterns that a single achievement test may not fully capture. Caviola et al. (2022) and Casey and Ganley (2021) add further nuance, showing that gender differences in mathematics performance are frequently mediated by affective factors such as math anxiety and self-efficacy rather than by cognitive ability itself.

This affective pathway is also supported by self-efficacy research more broadly. Zakariya (2022), in a systematic review of intervention studies, found that instructional approaches emphasizing active participation and mastery experiences—both central features of REACT—are among the most effective in strengthening students' mathematics self-efficacy. Appiah et al. (2022) further showed that a positive teacher-student relationship combined with strong self-efficacy predicts higher achievement regardless of gender, while Alkan and Özkaya (2023) demonstrated that self-efficacy mediates the relationship between attitude and achievement by reducing mathematics anxiety.

Lastly, the findings reveal no significant interaction effect of strategy and gender on students' achievement in mathematics, showing that gender does not influence the efficacy of the strategy. This corroborates the submission of Yildiz (2022), who concluded that individualised learning paths such as REACT emphasize collaborative in-class activities that foster an inclusive environment where all students can thrive regardless of gender. Also, Asanre et al (2025) established that an effective student-centered approach to learning improves mathematics achievement across a diverse student population. This is further situated within a coherent and expanding literature: Amidi et al (2025) and Fatkurochman et al (2024) both found that contextual, module-based mathematics instruction significantly improved students' mathematical literacy, while Zhang et al. (2022), analyzing TIMSS and PISA data, emphasized that classroom practices promoting active student engagement are consistently associated with higher achievement across international contexts. Hiltrimartin and Pratiwi (2025) additionally found that students' achievement-related emotions shift favorably under problem-solving-oriented instruction, an outcome that parallels the present study's finding of improved achievement without adverse gender-based effects.

Limitations

This study has several limitations that should be considered when interpreting its findings. The sample was relatively small, comprising 80 senior secondary school students from only two schools within a single local government area, thereby limiting the generalizability of the findings to broader populations. The relatively short intervention period may also have been insufficient to capture the sustained effects of the REACT strategy on mathematics achievement. In addition, the use of intact classes and class-level assignment, together with irregular school timetables and occasional classroom interruptions, may have influenced the consistency of the intervention. The study also focused primarily on mathematics achievement measured through a multiple-choice test and did not examine other relevant outcomes such as motivation, self-efficacy, engagement, or learner autonomy. Importantly, although the pedagogical principles of REACT were discussed in relation to distance mathematics education, the intervention

International Journal of
Didactic Mathematics in Distance Education
https://jurnal.ut.ac.id/index.php/ijdmde

itself was conducted entirely in a face-to-face classroom setting. Therefore, the findings should not be interpreted as direct evidence of the effectiveness of REACT in blended or distance learning environments.

Future Study

Future studies should involve larger and more diverse samples across multiple schools and geographical areas, employ longer intervention periods, and examine additional learning outcomes such as mathematical self-efficacy, motivation, engagement, anxiety, and learner autonomy. Particular attention should be given to systematically adapting and testing REACT in blended and fully distance mathematics learning environments. The five components of REACT could be redesigned for technology-mediated learning through contextual digital activities for Relating, interactive mathematical exploration for Experiencing, authentic online problem solving for Applying, synchronous or asynchronous peer interaction for Cooperating, and independent application to unfamiliar contexts for Transferring. Future research could also draw on transactional distance theory to investigate how REACT-based learning influences dialogue, instructional structure, and learner autonomy. Comparative studies across face-to-face, blended, and fully distance learning environments would provide stronger evidence regarding the extent to which REACT can function as a transferable pedagogical framework across different modes of mathematics instruction.

4. Conclusion

This study provides empirical evidence regarding the effectiveness of the REACT instructional strategy in improving senior secondary school students’ mathematics achievement within the Nigerian context. Students exposed to REACT demonstrated higher post-test achievement than those receiving conventional instruction, while gender and the interaction between instructional strategy and gender did not significantly influence achievement. These findings extend the application of REACT beyond contexts in which it has been more frequently investigated and indicate that its contextual, active, and collaborative characteristics can support mathematics learning for both male and female students. From a practical perspective, the findings highlight the value of integrating Relating, Experiencing, Applying, Cooperating, and Transferring into mathematics instruction to connect students’ prior experiences with mathematical concepts, promote active exploration and problem solving, facilitate collaborative mathematical reasoning, and encourage the application of knowledge to new situations.

Beyond the face-to-face classroom, the findings also provide a pedagogical basis for considering how REACT might be adapted to distance mathematics education. Its emphasis on contextualization, active experience, application, collaboration, and knowledge transfer corresponds with important pedagogical requirements of technology-mediated learning, particularly the need to maintain meaningful interaction while supporting increasingly independent learning. From a transactional distance perspective, the structured sequence of REACT may offer opportunities to strengthen dialogue, provide purposeful instructional structure, and support learner autonomy in blended and distance environments. Nevertheless, because distance education was not empirically examined in this study, these implications should be regarded as a basis for further investigation rather than evidence of effectiveness in distance settings. Future empirical studies are therefore needed to determine whether the achievement benefits observed in the present face-to-face context can be sustained when REACT is redesigned and implemented in blended and fully distance mathematics learning environments.

Acknowledgments

The authors sincerely appreciate the students who participated in the study, as well as the principals, mathematics teachers, and participating schools for their cooperation and support throughout the research process.

Author Contributions

Author 1: Conceptualization, Writing – Original Draft, Editing, and Visualization.
Author 2: Validation and Supervision.
Author 3: Writing – Review & Editing, and Methodology.

Funding Statement

This research received no external funding.

Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

Data Availability Statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request. The data are not publicly available to protect the privacy and confidentiality of the study participants.

AI Use Declaration

Generative artificial intelligence tools were used solely to support language refinement, improve grammatical clarity, and enhance the readability of the manuscript. AI tools were not used to generate or manipulate research data, conduct statistical analyses, or determine the study findings and conclusions. All AI-assisted content was critically reviewed and verified by the authors, who take full responsibility for the accuracy, integrity, and final content of the manuscript.

5. References

Agormor, S., Apawu, J., Aboagye-Agbi, J. J., & Hokor, E. K. (2022). Prior mathematics achievement and mathematics self-efficacy as indicators for success in preservice teachers' achievement in geometry and trigonometry. *Journal of Research in Instructional*, *2*(2), 115–128. https://doi.org/10.30862/jri.v2i2.83

Akinoso, S. O. (2015). Relevance of mathematics in everyday activities and career choices among secondary school students in Nigeria. *African Educational Research Journal*, *3*(4), 264–271.

Akkoç, H., & Ocak, G. (2019). Effect of constructivist learning approach on students' academic achievement in mathematics. *Journal of Education and Learning*, *8*(6), 60–72. https://doi.org/10.5296/jel.v8i6.15357

Alam, S., Budiarto, M. T., & Siswono, T. Y. E. (2022). A study of students' self-efficacy in mathematics performance based on Bugis ethnicity and gender. *European Journal of Mathematics and Science Education*, *3*(2), 155–170. https://doi.org/10.12973/ejmse.3.2.155

Alkan, M. F., & Özkaya, Ş. Y. (2023). An exploratory study on the effects of attitude and self-efficacy on math achievement as mediated by math anxiety. *Erzincan Üniversitesi Eğitim Fakültesi Dergisi*, *25*(3), 488–496. https://doi.org/10.17556/erziefd.1218193

Amidi, A., Kartono, K., Mulyono, M., & Pudjiastuti, E. (2025). The effectiveness of contextual teaching and learning with Articulate Storyline in improving mathematical literacy: A perspective of high self-confidence students. *Educational Process: International Journal*, *16*, Article e2025233. https://doi.org/10.22521/edupij.2025.16.233

Appiah, J. B., Korkor, S., Arthur, Y. D., & Obeng, B. A. (2022). Mathematics achievement in high schools, the role of the teacher-student relationship, students' self-efficacy, and students' perception of mathematics. *International Electronic Journal of Mathematics Education*, *17*(3), Article em0688. https://doi.org/10.29333/iejme/12056

Arroyo-Barrigüete, J. L., Carabias-López, S., Borrás-Pala, F., & Martín-Antón, G. (2023). Gender differences in mathematics achievement: The case of a business school in Spain. *SAGE Open*, *13*(2). https://doi.org/10.1177/21582440231166922

Asanre, A. A., Abiodun, T. O., & Odupe, T. A. (2019). Content coverage and students' attitude as predictors of senior secondary academic achievement in mathematics. *Islamic University Multidisciplinary Journal*, *6*, 164–167. https://iuiu.ac.ug/journaladmin/iumj/ArticleFiles/71009.pdf

Asanre, A. A., Sondlo, A., & Oluwadayo, A. T. (2024a). Effect of problem-based learning strategy on the learning outcomes of senior secondary school students in mathematics. *Journal of Advanced Sciences and Mathematics Education*, *4*(1), 15–23. https://doi.org/10.58524/jasme.v4i1.370

Asanre, A. A., Sondlo, A., & Oluwadayo, A. T. (2024b). Impact of interest and motivation on academic achievement of junior secondary school students in mathematics. *Journal of Mathematics Instruction, Social Research and Opinion*, *3*(3), 275–284. https://doi.org/10.58421/misro.v3i3.269

Asanre, A., Sondlo, A., & Adedeji, A. (2025). Evaluating the impact of the flipped classroom model on senior secondary students' mathematics achievement: A quasi-experimental study. *International Journal of Didactic Mathematics in Distance Education*, *2*(2), 128–140. https://doi.org/10.33830/ijdmde.v2i2.11774

Boateng, R. F., Charles, A. A., & Mohammed, S. (2023). Effect of REACT strategy on senior high school students' achievement in protein synthesis. *American Journal of Educational Research*, *11*(9), 620–627. https://doi.org/10.12691/education-11-9-11

Casey, B. M., & Ganley, C. M. (2021). An examination of gender differences in spatial skills and math attitudes in relation to mathematics success: A bio-psycho-social model. *Developmental Review*, *60*, Article 100963. https://doi.org/10.1016/j.dr.2021.100963

Caviola, S., Toffalini, E., Giofrè, D., Ruiz, J. M., Szűcs, D., & Mammarella, I. C. (2022). Math performance and academic anxiety forms, from sociodemographic to cognitive aspects: A meta-analysis on 906,311 participants. *Educational Psychology Review*, *34*(1), 363–399. https://doi.org/10.1007/s10648-021-09618-5

Çibukçiu, B. (2025). The impact of constructivist methods on students' mathematical problem-solving. *Discover Education*, *4*, Article 83. https://doi.org/10.1007/s44217-025-00475-w

Diwa, O. B., Ayuh, O. R., Osayi, U. H., & Bekom, A. K. (2023). Teachers' gender and effective classroom management and teaching methods as a dimension for teaching effectiveness of mathematics teachers in Ikom education zone of cross river state, Nigeria. *Global Journal of Educational Research*, *22*(1), 25–36.

Elbehary, S. G. A. (2024). Training Egyptian undergraduate mathematics students to implement REACT strategies: An approach to strengthen their conceptual and procedural knowledge of rational numbers and capability to create contextual situations. *Al-Jabar: Jurnal Pendidikan Matematika*, *15*(1), 171–215. https://doi.org/10.24042/ajpm.v15i1.21420

Fatkurochman, M., Slamet, I., & Pramudya, I. (2024). Contextually based mathematics learning module improves students' mathematical literacy abilities. *Journal of Educational Research and Evaluation*, *8*(1), 67–77. https://doi.org/10.23887/jere.v8i1.73940

Fisher, C., Berliner, D., Filby, N., Marliave, R., Cahen, L., & Dishaw, M. (2015). Teaching behaviors, academic learning time, and student achievement: An overview. *The Journal of Classroom Interaction*, *50*(1), 6-24. https://www.jstor.org/stable/44735708

Hiltrimartin, C., & Pratiwi, W. D. (2025). Problem-solving skills among students on the topic of derivatives: Differences in the changes of achievement emotions. *Eurasia Journal of Mathematics, Science and Technology Education*, *21*(6), Article em2645. https://doi.org/10.29333/ejmste/16504

Iroko, G. A., Adesina, K. A., & Asanre, A. A. (2024). Examining the influence of gender and school location on academic achievement in algebra among senior secondary school students. *FNAS Journal of Mathematics and Science Education*, *5*(4), 36–42.

Ismail, F. A., Bungsu, J., & Shahrill, M. (2022). Improving students' participation and performance in building quantities through think-pair-share cooperative learning. *Indonesian Journal of Educational Research and Technology*, *3*(3), 203–216. https://doi.org/10.17509/ijert.v3i3.50348

Johnson, E., Andrews-Larson, C., Keene, K., Melhuish, K., Keller, R., & Fortune, N. (2020). Inquiry and gender inequity in the undergraduate mathematics classroom. *Journal for Research in Mathematics Education*, *51*(4), 514–516. https://doi.org/10.5951/jresematheduc-2020-0043

Juwita, R., Wijayanti, D. A., & Haeruman, L. D. (2024). The effect of REACT learning strategy assisted structured worksheet on mathematical problem-solving ability. *Inovasi Matematika*, *6*(2). https://doi.org/10.35438/inomatika.v6i2.465

Kaiser, G., & Zhu, Y. (2022). Gender differences in mathematics achievement: A secondary analysis of Programme for International Student Assessment data from Shanghai. *Journal for STEM Education Research*. https://doi.org/10.1177/27527263221091373

Latri, A., & Agusalim, J. (2020). The influence of REACT learning strategies on mathematics learning outcomes and learning activities of fifth grade students at SDN Lariangbangi Makassar. *Jurnal Inovasi Pendidikan Matematika*, *8*(1), 32–39. https://doi.org/10.26858/jds.v8i1.13319

Lee, J., Lee, H. J., Song, J., & Bong, M. (2021). Enhancing children's math motivation with a joint intervention on mindset and gender stereotypes. *Learning and Instruction*, *73*, Article 101416. https://doi.org/10.1016/j.learninstruc.2020.101416

Majid, R. M., Nurhayati, A., & Ismail, D. (2024). REACT strategy on mathematical reasoning reviewed from students' interest in learning mathematics. *Journal of Humanities and Social Sciences Studies*, *6*(11), 89–97. https://doi.org/10.32996/jhsss.2024.6.11.8

Mashuri, S., & Yawan, H. (2023). Gender difference influence students' performance in learning math in secondary schools. *International Journal of Education, Social Studies, and Management*, *3*(1), 1–12. https://doi.org/10.52121/ijessm.v3i1.114

Musyadad, M. A., & Avip, B. (2020). Application of REACT (relating, experiencing, applying, cooperating, transferring) strategy to improve mathematical communication ability of junior high school students. *Journal of Physics: Conference Series*, *1521*, Article 032048. https://doi.org/10.1088/1742-6596/1521/3/032048

Ngozi, I. J., & Solomon, O. D. (2021). Effect of differentiated instruction on achievement of low mathematics achievers in primary schools in Abuja, Nigeria. *Innovare Journal of Education*, *9*(5), 37–43. https://doi.org/10.22159/ijoe.2021v9i5.42253

Nurzannah, M., Herizal, Fajriana, & Mursalin, M. (2021). The effect of REACT strategy assisted by GeoGebra software on students' mathematical representation ability. *Malikussaleh Journal of Mathematics Learning*, *4*(2), 90–97. https://doi.org/10.29103/mjml.v4i2.5709

Origenes, M. J. G. (2025). The effectiveness of the constructivist approach on students' achievement in mathematics: A meta-analysis. *International Journal of Advanced*

Multidisciplinary Research and Studies, *5*(6). https://doi.org/10.62225/2583049X.2025.5.6.5308

Pena, M., Olmedo-Torre, N., de les Valls, E. M., & Lusa, A. (2021). Introducing and evaluating the effective inclusion of gender dimension in STEM higher education. *Sustainability*, *13*(9), Article 4994. https://doi.org/10.3390/su13094994

Prieto-Saborit, J. A., Mendez-Alonso, D., Fernandez-Viciana, A., Dixit, L. J. D., & Nistal-Hernandez, P. (2022). Implementation of cooperative learning and its relationship with prior training of teachers, performance and equity in mathematics: A longitudinal study. *Sustainability*, *14*(23), Article 16243. https://doi.org/10.3390/su142316243

Quainoo, B. A., Otami, C. D., & Owusu, K. A. (2021). Effect of the REACT strategy on senior high school students' achievement in molecular genetics. *LUMAT: International Journal on Math, Science and Technology Education*, *9*(1). https://doi.org/10.31129/LUMAT.9.1.1418

Sihite, M. S. R., & Pangaribuan, L. R. (2023). Implementation of cooperative learning model with REACT strategies to improve student mathematical problem-solving ability. *International Journal of Educational Research & Social Sciences*, *4*(2), 320–327. https://doi.org/10.51601/ijersc.v4i2.628

Siller, H.-S., & Ahmad, S. (2024). Analyzing the impact of collaborative learning approach on grade six students' mathematics achievement and attitude towards mathematics. *Eurasia Journal of Mathematics, Science and Technology Education*, *20*(2), Article em2395. https://doi.org/10.29333/ejmste/14153

Ugwuozor, F. O. (2020). Constructivism as pedagogical framework and poetry learning outcomes among Nigerian students: An experimental study. *Cogent Education*, *7*(1), Article 1818410. https://doi.org/10.1080/2331186X.2020.1818410

Xu, Z., & Shi, Y. (2018). Application of constructivist theory in flipped classroom—Take college English teaching as a case study. *Theory and Practice in Language Studies*, *8*(7), 880–887. https://doi.org/10.17507/tpls.0807.21

Yildiz, E. P. (2022). Teacher Education in the Digital Transformation Process in North Cyprus: A Situation Analysis Study. *International Education Studies*, *15*(1), 187-199. https://doi.org/10.5539/ies.v15n1p187

Zakariya, Y. F. (2022). Improving students' mathematics self-efficacy: A systematic review of intervention studies. *Frontiers in Psychology*, *13*, Article 986622. https://doi.org/10.3389/fpsyg.2022.986622

Zhang, Y., Russell, S., & Kelly, S. (2022). Engagement, achievement, and teacher classroom practices in mathematics: Insights from TIMSS 2011 and PISA 2012. *Studies in Educational Evaluation*, *73*, Article 101146. https://doi.org/10.1016/j.stueduc.2022.101146

Zulkarnain, S. H., Hutkemri, Z., & Suraji. (2021). Effects of REACT learning model based on Riau–Malay culture towards mathematical problem-solving ability and achievement motivation amongst high school students. *Turkish Journal of Computer and Mathematics Education*, *12*(4), 869–880.