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Inclusive Pedagogies in Mathematics Education: Experiential Learning for Deaf Learners in Specialized Settings

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ABSTRACT

In this paper, we examined the effects of experiential learning combined with collaborative teaching on the mathematics achievement of deaf learners in specialized classrooms. A quasi-experimental design was employed, comparing pre-test and post-test scores of a control group that received traditional instruction with those of an experimental group taught through experiential learning using collaborative methods. Both groups showed improvement, but the experimental group demonstrated significantly greater gains. Findings confirm the effectiveness of learner-centered approaches in enhancing engagement and understanding among deaf students. The study aligns with global education reform efforts that advocate for inclusive, adaptive teaching practices. It highlights the importance of

innovative pedagogies in addressing diverse learner needs and promoting equitable outcomes, particularly in specialized and cross-cultural educational settings.

Keywords: Collaborative Teaching, Deaf Learners, Experiential Learning, Mathematics Achievement, Quasi-Experimental Design, Specialized Classrooms, Teacher Training

INTRODUCTION

Mathematics is widely recognized as a foundational discipline that cultivates essential cognitive abilities such as logical reasoning, analytical thinking, and problem-solving, all of which are vital not only for academic success but also for navigating real-world challenges (Szabo, Körtesi, Guncaga, Szabo, & Neag, 2020). However, for deaf learners, attaining mathematical competence presents distinct challenges, particularly within specialized classrooms where conventional pedagogical strategies often fail to accommodate their unique communicative and cognitive needs. Traditional mathematics instruction—typically reliant on auditory, lecture-based delivery, remains largely misaligned with the visual-spatial and experiential learning preferences that characterize many deaf learners (Nunes, 2020; Alam & Mohanty, 2023).

This pedagogical mismatch contributes to persistently low mathematics achievement among deaf students, despite decades of advocacy for inclusive and differentiated instruction (DeMatthews, Serafini, & Watson, 2021). In many specialized educational settings, mathematics continues to be taught through rote memorization, passive reception of knowledge, and minimal engagement with hands-on or real-life contexts. These methods not only neglect the strengths of deaf learners but also overlook the growing body of research suggesting that active, multimodal engagement is crucial for conceptual understanding, especially in mathematics (Klein, 2024).

In response, educational researchers and practitioners have begun to explore experiential learning as a promising alternative. Grounded in the work of Dewey and Kolb, experiential learning emphasizes direct experience, reflection, and active problem-solving as central to the learning process. This approach holds promise for deaf students, whose learning is often enriched through visual, tactile, and kinesthetic modalities. When paired with collaborative teaching models—where two or more educators with complementary skills co-plan, co-instruct, and co-assess—the potential for meaningful and inclusive mathematics instruction is further amplified. Collaborative teaching not only enhances communication dynamics in the classroom but also provides diversified instructional strategies that can cater to the varied needs of deaf learners (Bryant, 2023; Blanton, 2023).

Despite the theoretical appeal of integrating experiential learning and collaborative teaching, empirical evidence on their combined effectiveness within

specialized classrooms for deaf learners remains scarce (Tshabalala, 2023). This gap is particularly pronounced in the context of mathematics education, where traditional instructional paradigms continue to dominate. Few studies have systematically examined whether and how these innovative pedagogical approaches can improve the academic achievement of deaf students in mathematics (Mulenga, & Marbán, 2020).

This study seeks to address that gap by examining the effectiveness of experiential learning combined with collaborative teaching on the mathematics achievement of deaf learners in specialized Junior High School classrooms. The study examines whether this integrated approach yields measurable improvements over traditional instructional methods. The research aims to contribute robust evidence to ongoing efforts in inclusive education reform. Furthermore, the findings may offer critical insights for policymakers, curriculum developers, and special education practitioners seeking to implement pedagogies that are not only accessible but also empowering for deaf learners.

LITERATURE REVIEW

Theoretical Foundations of Experiential Learning

Experiential Learning Theory (ELT) proposed by David Kolb (1984) posits that learning is a process of experiencing wherein knowledge arises from the process of experience transformation. One of the four-step cycles mentioned by Kolb's model comprises: (1) Concrete Experience, (2) Reflective Observation, (3) Abstract Conceptualization, and (4) Active Experimentation. ELT is founded upon the pillars of thought of John Dewey, Jean Piaget, and Kurt Lewin, who each emphasized active, student-centered, experiential involvement in the learning process (Passarelli & Kolb, 2023). Experiential learning is also most suitable for deaf children because they prefer visual and kinesthetic modes. It enables them to connect abstract mathematical ideas to real-world examples and concrete experience, bridging the gaps resulting from communication constraints (Marshall, Carrano, & Dannels, 2016; Lang & Pagliaro, 2007).

Empirical Review

The persistent underachievement of deaf learners in mathematics remains a critical issue in special education research, especially in specialized classroom settings where traditional pedagogies often fail to meet the diverse needs of these learners. The existing academic discourse highlights that conventional, auditory-dependent mathematics instruction systematically disadvantages deaf students, contributing to a persistent performance gap between deaf and hearing learners (Nunes, 2020). These instructional limitations—rooted in verbal explanations and didactic delivery—do not cater to the visual, tactile, and interactive learning preferences commonly observed among deaf students. As such, the urgency for alternative, inclusive pedagogical approaches is growing.

Against this backdrop, the central argument of this study is that combining experiential learning with collaborative teaching can significantly improve the mathematics achievement of deaf learners in specialized classrooms. These two instructional strategies, though individually validated in various educational contexts, have seldom been empirically examined together, especially in deaf education. This paper posits that their integration could provide a robust instructional framework that aligns with the linguistic, cognitive, and social needs of deaf students, ultimately narrowing the achievement gap in mathematics.

Experiential Learning and Deaf Learners' Mathematical Achievement

Experiential learning, grounded in Kolb's (1984) theory, emphasizes learning through direct experience, reflection, and active experimentation. This approach resonates strongly with the learning needs of deaf students, whose education often relies on visual and hands-on engagement rather than auditory input (Adeduyigbe, Adeduyigbe, & Tijani, 2024). Several studies affirm the positive impact of experiential learning on deaf learners' mathematical understanding. For example, Stanziale (2024), asserts that deaf students exposed to geometry instruction involving manipulatives and real-life applications outperformed those in traditional, lecture-based classrooms. Rehman, Huang, and Mahmood (2025), similarly found that enhanced problem-solving abilities and retention rates among students participating in project-based and visually enriched mathematics lessons.

These findings underscore the argument that experiential learning is not simply an enrichment strategy, but a necessary pedagogical realignment for deaf education. However, while the benefits of experiential learning are well-documented, the literature rarely explores how its effectiveness may be further enhanced through integration with other inclusive instructional models—most notably, collaborative teaching.

Collaborative Teaching in Deaf Education

Barron and Friend (2025) assert that collaborative teaching, or co-teaching, involves two or more educators working in tandem to plan, deliver, and assess instruction for a shared group of students. While often used in inclusive classroom settings, its application in specialized deaf classrooms remains under-researched. Empirical findings by Bryant (2023), reveal that collaborative teaching enhances the learning experiences of deaf students by reducing communication barriers, supporting differentiated instruction, and enriching classroom discourse with sign-supported and visually structured content.

From a theoretical standpoint, collaborative teaching is anchored in Vygotsky's sociocultural theory and the concept of the Zone of Proximal Development (ZPD), which emphasizes learning as a socially mediated process. Co-teaching enables scaffolding, dual perspectives, and the flexibility necessary to tailor instruction to the specific needs of deaf learners. Additionally, Universal Design for Learning (UDL) and social constructivist theories also endorse

collaborative pedagogy for supporting varied learner profiles (Mohd Hashim & Tasir, 2020; Sanguinetti, 2024).

Despite these promising indications, most existing research focuses on inclusive settings rather than specialized environments. Furthermore, the potential synergistic effects of combining collaborative teaching with experiential learning remain largely unexplored, particularly in the context of mathematics instruction for deaf students.

Integrating Experiential Learning and Collaborative Teaching

Preliminary studies offer promising yet limited insights into the combined implementation of these pedagogies. Tshabalala (2023) reported that in inclusive classrooms, students exposed to experiential learning co-facilitated by multiple teachers demonstrated substantial gains in mathematics performance. In a deaf education context, field-based projects co-taught by a mathematics teacher and a sign language interpreter resulted in improved mathematics performance and increased engagement among deaf learners (Wall, 2023).

These findings suggest that integrating experiential learning and collaborative teaching may offer a transformative approach in specialized classrooms—where instructional coherence, engagement, and communication are critical. This combination not only reinforces mathematical concepts through hands-on activities but also ensures accessibility and instructional scaffolding via team-teaching strategies.

Addressing the Empirical Gap

While experiential learning and collaborative teaching are individually supported by substantial empirical and theoretical foundations, their combined application in deaf education, especially in specialized mathematics classrooms, remains largely under-researched. This represents a critical gap in both practice and policy. There is a pressing need to move beyond fragmented pedagogical interventions toward integrated teaching models that holistically support the cognitive, linguistic, and social development of deaf learners.

In sum, this study seeks to contribute to this underexplored area by empirically evaluating whether deaf learners taught mathematics through an integrated model of experiential learning and collaborative teaching perform better than those instructed through traditional methods. By doing so, the research aims to inform the development of more inclusive and effective teaching practices, contribute to equity in mathematics education, and establish a robust pedagogical foundation for specialized deaf classrooms. Ultimately, this study envisions a shift from deficit-oriented approaches toward empowering pedagogies that recognize and build upon the unique strengths and learning modalities of deaf students.

Statement of the Problem

Deaf pupils in special rooms are likely disadvantaged in achieving optimal mathematics performance due to teaching practice that is not necessarily

aligned with their specific learning needs (Kahn, 2023). Traditional practices of full auditory instruction and limited interactive involvement can compromise their comprehension and memorization of mathematics. Despite the promise of facilitating improved education through experiential learning with collaborative teaching, empirical research to establish the role of these methodologies on deaf students' mathematics performance in special education is not forthcoming. The focus of the current study was therefore to fill this gap by investigating whether the introduction of experiential learning with collaborative teaching differs from what exists under conventional instruction methods in regard to deaf learners' mathematics accomplishment. The objective of the study was to compare deaf students' mathematical achievement who were instructed using experiential learning with collaborative teaching strategies with those instructed using traditional modes of instruction.

RESEARCH METHOD

This study employed quasi-experimental pre-test–post-test control group design to determine the effectiveness of experiential learning with collaborative teaching in improving deaf students' performance in mathematics. Experiential learning activities were designed in accordance with the learning objective as outlined in the basic school mathematics curriculum. In this case, the learners were engaged with those experiential learning activities that had been designed by the basic school teachers and the researcher. As the activities were being done, the students were given an opportunity to sense and live real learning activities within and beyond classroom. Experiential learning activities were designed on the concept of statistics (finding the mean from frequency distribution tables) and fractions. Exercises were not selected from school-supplied books. But students were compelled to describe their own experiences because they go through the learning and teaching process. The teachers were compelled to instruct control-specialized class as well as experimental-specialized class because of their proficiency in the range and content of the basic school mathematics. During experiential learning with collaborative instruction, students were taught by the experiential learning activities designed by the researcher in consultation with mathematics teachers. Prior and subsequent to experimentation, both groups were given mathematics achievement test of what was to be taught during the three months' period of instruction. This was aimed at measuring how the performance of the learners has improved in both groups, within the three months learning and instruction.

Research Design in Teaching Mathematics to Deaf Students

Junior high school form 3 students from the Tetteh Ocloo school for the deaf, located at Adjei Kojo in the Ashaiman Municipality of the Greater Accra Region of Ghana, constituted the population for this research. The use of simple random and purposive sampling method was applied in the selection of students

for this research. The students' population from this class (form 3) is eighty (80) deaf learners. The school was selected on the grounds of purpose because Tetteh Ocloo State School for the deaf is a special school for the deaf which is the main focus of this study. Sixty (60) pupils were selected using simple random sampling technique, out of which six of them were severely ill mentally and hence were excluded from the sample leaving fifty-four deaf learners for the study. The study sample was divided into two groups of twenty-seven (27) pupils each, one for the control group and the other for the experimental group. All seven Junior High School mathematics teachers of both schools participated in the study to ensure the implementation of experiential learning with collaborative teaching methods.

Experiential learning activities were prepared in collaboration with the seven Junior High School mathematics teachers. This was greatly needed since the teachers were asked to implement the teaching during the experiment. In order not to disrupt class teaching and learning, the research was held on Fridays at 1 pm for 60 minutes. In control group, students were provided with extra exercises from books which were available for students and teachers. Mathematics instructors of both Junior High Schools provided lessons simultaneously on topics such as statistics and fractions and other mathematics topics to control and experimental groups for three months. Six mathematics teachers were assigned to experimental class and one assigned to control class. All seven teachers were expert in using sign language for lesson delivery.

Teaching Statistics through Experiential Learning with Collaborative Approaches in Specialized Deaf Classrooms

One of the experiential learning lessons delivered using collaborative teaching approaches was on the topic of *Statistics* for Junior High School Form 3 deaf students in a specialized school setting. The students were divided into two groups: the experimental group, which received instruction through experiential learning with collaborative teaching, and the control group, which was taught through traditional methods.

In the experimental class, the lesson followed Kolb's experiential learning cycle to support deep understanding of statistical concepts and active learner participation. The lesson began with a concrete experience, where students engaged in a real-life data collection activity. Collaborative teachers (two subject teachers and a co-teacher using sign language) guided students through a practical task of surveying their classmates on their favorite fruits. Visual aids such as real fruits, picture cards, and labeled signs were used to support understanding and communication. Students, working in small groups, moved around the classroom asking each peer about their favorite fruit using sign language. As responses were gathered, they recorded them using tally marks on prepared data sheets.

Once the data was collected, students were introduced to a frequency distribution table. The collaborative teachers helped each group to organize their

data into a structured table with three columns: *Fruit Type*, *Tally Marks*, and *Frequency*. For example:

Fruit Type	Tally Marks	Frequency
Banana		
Apple		
Mango		

The frequency table provided a clear summary of the data collected and supported visual learning, which is essential for deaf students.

In the reflective observation stage, students were encouraged to discuss and reflect on the experience of collecting and organizing data. The collaborative teachers guided them in thinking about how the activity was conducted: How did they gather responses? Was communication between group members smooth? Did the use of tally marks and tables help them understand the results better? These reflective discussions, conducted in sign language, allowed students to consider their own roles, group interactions, and how the tools used helped make sense of the data.

Next, in the abstract conceptualization stage, the collaborative teachers helped students connect their practical experience with formal mathematical concepts. Using the frequency distribution table as a reference, the teachers explained key statistical terms such as “frequency,” “category,” and “most/least popular.” Students then learned how to use the information in their tables to create bar graphs and pictograms. For example, students saw how each bar on a graph represents a fruit and the height of the bar shows how many students liked that fruit. In a pictogram, one fruit symbol might represent two students. This visual modeling helped reinforce abstract concepts in a concrete way.

The final stage, active experimentation, required students to apply their learning in a new but related context. Each group was tasked with choosing a new topic for data collection, such as the number of siblings each student has or their preferred school subject. They followed the same process: preparing survey questions, collecting data using sign language, organizing responses into a frequency distribution table, and then creating a bar graph or pictogram based on the data. Each group presented their results to the class using sign language and visual supports such as charts and posters. Through this process, students developed not only statistical understanding but also communication and teamwork skills.

After the experiential learning sessions, a constructed-response test item was administered to both the experimental and control groups to assess understanding of the topic. One such item focused on interpreting a real-life scenario:

Your group surveyed the class on the number of siblings each person has. The data collected is:

- 1 sibling: 4 students
- 2 siblings: 6 students
- 3 siblings: 5 students
- 4 or more siblings: 3 students

Tasks:

1. Create a frequency distribution table based on this data.
2. Draw a bar graph representing the data.
3. Which number of siblings is the most common in the class?
4. How many students were surveyed in total?

This lesson on statistics illustrated the effectiveness of using experiential learning combined with collaborative teaching in specialized classrooms for deaf learners. Students in the experimental group actively participated in real-world data collection, learned how to construct and interpret frequency tables and graphs, and communicated their findings visually and through sign language. The use of visual aids, structured group work, and practical application allowed them to build strong conceptual foundations in statistics while developing collaborative and communicative competence.

Teaching Fractions through Experiential Learning with Collaborative Approaches in Specialized Deaf Classrooms

A lesson on the topic of *Fractions* was conducted with Junior High School Form 3 deaf students in specialized classrooms. The students were divided into two groups: an experimental group, which was taught through experiential learning combined with collaborative teaching, and a control group, which received conventional instruction. The objective was to help deaf students build a strong conceptual understanding of fractions through hands-on, visual, and interactive learning experiences facilitated by a team of collaborative teachers.

In the experimental group, the lesson was designed according to Kolb's experiential learning cycle. The first stage, concrete experience, began with a familiar, real-world activity: sharing food. Collaborative teachers introduced the concept of fractions using physical objects such as slices of bread, fruits (like oranges or apples), and rectangular paper strips. Each group was given items to divide equally among members. For instance, a loaf of bread was cut into equal parts, and students discussed how many parts were made and how many each person received. Through this, the concept of *halves*, *thirds*, and *fourths* became visually and physically meaningful. Sign language, demonstration, and peer interaction were central throughout the activity.

Following the hands-on task, students entered the reflective observation stage. Here, they were asked to reflect on their experiences of sharing and dividing. The collaborative teachers facilitated the reflection by posing questions in sign language, such as: "How many people shared one item?", "How many pieces did

we divide it into?”, and “Did everyone get an equal part?” Students were also encouraged to compare quantities and express their observations—for example, “One-fourth is smaller than one-half.” This reflection helped them to recognize patterns and start internalizing fraction relationships.

In the abstract conceptualization stage, students moved from experience to theory. The collaborative teachers introduced mathematical symbols and formal definitions of fractions. Using visuals like fraction circles, fraction bars, and number lines, teachers helped students understand numerator and denominator. The lesson progressed to comparing fractions, recognizing equivalent fractions (e.g., $\frac{2}{4} = \frac{1}{2}$), and simple addition and subtraction of like fractions. Collaborative teaching ensured that one teacher modeled with manipulatives while another reinforced with sign language and simplified explanations. Deaf students were also given opportunities to represent fractions on fraction strips and explain their understanding using gestures, visuals, or written responses.

In the final stage, active experimentation, students were assigned group tasks that allowed them to apply their understanding of fractions in new scenarios. One such task involved a "Fraction Pizza Project." Each group was given a cardboard pizza template divided into equal parts. They were told: “Half of the pizza will be cheese, one-fourth will be pepperoni, and one-fourth will be vegetables.” Students used colored paper to decorate the sections accordingly. In another task, students measured and marked fractional parts of a meter stick or a water bottle using real-life measurements (e.g., filling a 1-liter bottle to one-half or one-quarter). These activities strengthened the practical relevance of fractions and helped reinforce understanding through doing.

To assess students' understanding of the topic, a constructed-response test item was administered to both the experimental and control groups. The question was designed to reflect a real-life scenario familiar to the students:

Your class is organizing a snack day. A cake was cut into 12 equal slices.

- *Ama ate 3 slices, Kofi ate 2 slices, and Efua ate 1 slice.*

Questions:

1. What fraction of the cake did Ama eat?
2. What fraction did Kofi and Efua eat together?
3. What fraction of the cake was eaten in total?
4. What fraction of the cake is left?
5. If the remaining cake is shared equally among 3 students, what fraction will each student get?

This assessment aligned well with the lesson objectives and provided students an opportunity to demonstrate their understanding of fractional parts, addition and subtraction of fractions, and sharing in a real-world context. It also reflected their learning through hands-on group tasks like the "Fraction Pizza Project" and measuring with real-life items. The question encouraged reasoning, communication, and visual thinking—all key elements for supporting deaf learners in mathematics through experiential learning.

Fifty (50) objective response test items were administered to the students, covering all areas within the three months for both the experimental and control groups. The test was administered for one (1) hour duration and scored out of 50 marks, converted as a percentage, and the two groups responded to the same questions at the same time. The test was designed to determine which mode of instruction was more effective for classroom learning and teaching. The tests were administered to an expert for evaluation to determine content validity. The tests were piloted in a comparable environment for clarity, relevance, and alignment to research questions. This was most urgently needed to establish consistency between the instruments and the research aim, and to remove vague items.

Administration of Pre-Test and Post-Test in Specialized Deaf Classrooms

To assess the impact of experiential learning integrated with collaborative teaching on the mathematics achievement of deaf students, pre-tests and post-tests were administered to both experimental and control groups at the Tetteh Ocloo State School for the Deaf, located in Adjei Kojo, Ashaiman Municipality, Greater Accra Region. A total of 54 deaf students in Junior High School, specifically in Form 3, were randomly assigned into two equal groups of 27 each. One group served as the experimental group and received instruction through experiential with collaborative teaching methods, while the control group received conventional instruction.

The **pre-test** was administered before the instructional intervention during regular school hours in the classroom. It assessed students' knowledge of topics including fractions, statistics, area of plane figures, and other mathematics topics during the three-month duration of teaching and learning. Test items were adapted to meet the cognitive and language needs of deaf learners, utilizing clear visuals, diagrams, and simple sign-supported instructions. The administration was supervised by mathematics teachers fluent in Ghanaian Sign Language (GSL), who ensured that students clearly understood the instructions without providing assistance that could influence their responses.

After a three-month teaching period, a **post-test** was administered under the same conditions to both groups. The post-test mirrored the structure and content of the pre-test, with slight variations to reduce recall bias. It maintained the use of visuals and accessible language to support the learning needs of deaf students. The post-test aimed to measure students' learning gains and the effectiveness of the instructional approach used in each group.

Throughout the testing process, measures were taken to maintain fairness, minimize anxiety, and ensure a valid assessment. All scripts were securely collected for scoring and comparison. The results from the pre- and post-tests served as the basis for evaluating improvements in mathematical understanding and the effectiveness of experiential learning with collaborative teaching approaches in specialized classrooms for deaf learners.

RESULTS

Research Question: How does mathematics achievement of deaf learners taught through experiential learning with collaborative teaching methods differ compared to those taught through traditional instructional approaches in specialized classrooms?

Table 1: Paired Samples t-Test Results for the Control-Specialized Class

Pair	Mean Difference	SD	SE	95% CI (Lower)	95% CI (Upper)	T	Df	P
Posttest – Pretest	8.74	4.50	0.87	6.96	10.52	10.09	26	< .001

Note. SD = Standard deviation; SE = Standard error; CI = Confidence interval. A paired samples t-test was conducted to compare pretest and posttest scores in the control class.

This is the result of a Paired Sample Test, which was conducted on the control group, in a specialized classroom of deaf learners. This control group received no instruction based on experiential learning with collaborative teaching strategies. The test was conducted to determine if differences between pre-test and post-test scores were significant in this group. The post-test and pre-test mean difference for the control group was 8.741. This positive value indicates that, on average, the participants in the control group scored more highly on the post-test than on the pre-test (Frimpong, Agyei, Apaak, Ansah, & True, 2022). Meanwhile, it is necessary to consider whether this difference is statistically significant.

Table 2: Paired Samples t-Test Results for the Experimental-Specialized Class

Pair	Mean Difference	SD	SE	95% CI (Lower)	95% CI (Upper)	T	Df	P
Posttest – Pretest	16.04	6.14	1.18	13.61	18.47	13.57	26	< .001

Note. SD = Standard deviation; SE = Standard error; CI = Confidence interval. A paired samples t-test was conducted to compare pretest and posttest scores in the experimental-specialized class.

Analysis of the experimental-specialized classroom setting that was taught via experiential learning with collaborative/team-teaching approaches shows tremendous results for the effectiveness of the teaching practices. The average difference between post-test and pre-test scores is mentioned as 16.037, which

implies that there has been a vast improvement in students' performance subsequent to the intervention (Stewart, 2023). That the mean difference is positive means that the innovative approaches to instruction applied were successful in enhancing the learning achievements of the participants. The standard deviation of the differences stands at 6.142, which is the deviation in improvement in scores among the students. That there is variability means that while the majority of the students had significant improvements in their post-test scores, there are also deviations in the extent of improvement (Nantha, Pimdee, & Sitthiworachart, 2022).

The independent samples t-test results in Table 3 show no significant difference between the experimental and control groups at the pre-test stage ($p = .086$), indicating comparable baseline performance. However, a statistically significant difference was observed in the post-test scores ($p = .001$), with the experimental group outperforming the control group by a mean difference of 5.85 points, confirming the effectiveness of the experiential and collaborative teaching intervention. The results unequivocally show that the instructional approaches used by the experimental class led to a statistically significant improvement in students' performance, bearing witness to the effectiveness of innovative pedagogy methods in promoting learning achievements (Daniel, Msambwa, Antony, & Wan, 2024).

This comparison examines the pre-test and post-test scores of the control group to those of the experimental group in the specialized classroom settings. The control group received no treatment, while the experimental group were exposed to different teaching methods, such as experiential learning with collaborative teaching. An Independent Samples Test was used to compare whether there were differences between the groups on the pre-test and post-test. The equality of means t-test gave a non-significant p-value of 0.086 for equal and unequal variances assumed. This means that the groups began with comparable levels of skill or knowledge prior to the intervention.

There was a notable difference between the experimental and control group on the post-test. The t-test for equal or unequal variances is assumed provided with a significant p-value of less than 0.001. This indicates that on average, the experimental groups scored significantly better than the control group on the post-test. The wide post-test difference in scores reflects the effectiveness of the instructional techniques used with the experimental groups in increasing student learning (Zsigmond, Metallidou, Misailidi, Iordanou, & Papaleontiou-Louca, 2025). The control group, which was given no special treatment, failed to significantly change. This reflects the potential benefits of using experiential learning with collaborative teaching within learning environments (Anderson, Coleman-King, Wallace, & Harper, 2022). Lastly, the results of the Independent Samples Test provide evidence that the experimental group taught with experiential learning with collaborative teaching outperformed the control group on the post-test. This outcome suggests that these instructional techniques are

effective in enhancing student learning outcomes. (Guo, Jantharajit, & Thongpanit, 2024).

DISCUSSION

The study examined the effects of experiential learning integrated with collaborative teaching on the mathematics achievement of deaf learners in specialized classrooms by comparing pre-test and post-test results from both control and experimental groups. Students in the control group received traditional instruction, while those in the experimental group were exposed to experiential learning supported by collaborative teaching methods.

From Table 1, the Paired Samples Test for the control group revealed a mean score difference of 8.741 between post-test and pre-test results. This positive mean indicates that, on average, students performed better after instruction, despite not receiving the experiential learning intervention. The t-test statistic was 10.086, with 26 degrees of freedom (df), and a p-value less than .001, indicating a statistically significant improvement in post-test scores (Hassan, 2022). Thus, the null hypothesis of no difference between pre- and post-test scores is rejected. The 95% confidence interval for the mean difference ranged from 6.959 to 10.522, suggesting with high certainty that the average improvement in student performance lies within this range (Fakhrunnisa, 2020). These findings demonstrate that although experiential learning was not applied, learning still occurred through conventional teaching approaches (Rudolph, Tan, & Tan, 2023). In contrast, Table 2 presents the analysis for the experimental group, which experienced instruction through experiential learning with collaborative teaching. Here, the mean difference between pre-test and post-test scores was an impressive 16.037, reflecting a substantial improvement in performance due to the intervention (Frimpong, Agyei, Apaak, Ansah, & True, 2022). This suggests that the instructional methods implemented were highly effective in promoting mathematical achievement among deaf learners. (Murungi, Awori, & Wamocho, 2025). The standard deviation of 6.142 shows some variability in the degree of improvement among students, which could be attributed to differences in learning styles, prior knowledge, and level of involvement during the activities. The standard error of the difference was calculated at 1.182, indicating a high level of precision in the estimation of the mean difference, thereby strengthening the validity of the results (Abdullah, Arifin, Saro'I & Uhai, (2024).

The 95% confidence interval for the mean difference in the experimental group ranged from 13.607 to 18.467, and since both limits are positive, this strongly confirms a substantial improvement in post-test scores. This result is reinforced by the t-test statistic of 13.566 with 26 degrees of freedom, yielding a p-value of 0.000. As this value is far below the conventional threshold of 0.05, the null hypothesis is once again rejected, affirming that the difference between pre-test and post-test scores is statistically significant (Das, Jha, Sahu, Yadav, Raman, & Kartikeyan, 2022).

These results validate the effectiveness of experiential learning with collaborative teaching in improving academic achievement among deaf learners. The findings are consistent with existing literature, such as Barone and Crişan (2023), which highlights the benefits of these approaches in boosting student engagement, understanding, and performance. Additional research supports these results, with scholars such as Dessie, Gebeyehu, and Eshetu (2023) emphasizing that experiential learning enhances students' conceptual understanding of mathematics, retention, and problem-solving abilities. Similarly, Jawad, Majeed, and ALRikabi (2021), as well as Dolapcioglu and Doğanay (2022), affirm that practical, real-life applications of mathematical concepts facilitate deeper understanding, critical thinking, and long-term academic success.

In conclusion, the statistically significant improvements observed in the experimental group underscore the pedagogical value of experiential learning with collaborative teaching methods, particularly in specialized settings for deaf learners. These methods not only enhance learning outcomes but also foster a more meaningful and engaging educational experience (Fadare, Fadare, Adlawan, & Espino, 2024).

Cross-Cultural and Higher Education Reform Reflection

The findings of this study, which show a clear advantage of experiential learning with collaborative teaching for deaf learners, resonate with global calls for reimagining teaching practices in higher and specialized education (Taneja-Johansson, & Singal, 2025). Across various educational contexts—be it Globally, scholars and reform advocates are emphasizing a shift from teacher-centered instruction to student-centered, participatory models. The use of experiential learning in this study aligns with these reformist paradigms by valuing learners' active participation and contextual understanding, which is especially critical for marginalized groups such as deaf students (Awacorach, Jensen, Lassen, Olanya, Zakaria, & Tabo, 2021).

From a comparative education perspective, traditional didactic models—such as those used with the control group—still dominate many national curricula, particularly in countries where access to training in inclusive pedagogies is limited (Mateus, Andrada, González-Cabrera, Ugalde, & Novomisky, 2022). Yet, international frameworks such as UNESCO's Education 2030 agenda and the Convention on the Rights of Persons with Disabilities (CRPD) underscore the necessity of inclusive, equitable quality education for all learners, including those with disabilities. These frameworks encourage adaptive and culturally relevant pedagogies, much like the experiential and collaborative methods utilized in your study (Nassar, Abbas, & Al-Sify, 2024).

Moreover, the statistically significant improvement in the experimental group suggests that interactive, multimodal strategies can transcend linguistic and cultural barriers, making them adaptable for use in diverse cross-cultural settings (Xia, Shin, & Kim, 2024). For example, in Finland, experiential education is deeply integrated into the curriculum and is credited for strong student outcomes,

including among learners with special needs. Similarly, in parts of Sub-Saharan Africa and South Asia, grassroots initiatives are emerging that employ community-based and experiential approaches to support deaf learners, despite systemic challenges (Lavonen, & Salmela-Aro, 2022).

This study contributes to this growing international body of work by demonstrating empirical evidence that supports these global reforms in the specific context of deaf education. (Ali, 2020). It affirms that when instruction is designed around the learner's sensory and communication needs, not only is academic performance improved, but learner motivation and engagement are also enhanced, a point emphasized in cross-cultural studies (Barone & Crişan 2023; Dessie, Gebeyehu, & Eshetu, 2023).

This reflection further underscores the need for teacher education programs worldwide to integrate experiential and collaborative methods into training, especially for those working with learners who are deaf or otherwise marginalized (Wainscott, 2025). Doing so supports not only improved learning outcomes but also the realization of inclusive education as a human right—ensuring that pedagogical equity is not constrained by geography, language, or ability.

DISCUSSION AND CONCLUSIONS

This research aimed to evaluate the effectiveness of experiential learning combined with collaborative teaching in improving mathematics achievement among deaf students in specialized classrooms. Findings revealed that the experimental group, taught using these interactive and learner-centered methods, significantly outperformed the control group taught through traditional approaches (Doyle, & Zakrajsek, 2023). The results highlight that experiential learning offers real, visual, and hands-on experiences essential for deaf learners' conceptual understanding, while collaborative teaching helps address communication challenges and fosters active engagement. (Baxtiyor, & Ruslanovna, 2025). Overall, the study highlights the importance of adaptive teaching strategies and advocates for innovative, inclusive approaches to improve academic outcomes for deaf students.

The findings of this study is well situated within the global dialogue on pedagogical innovation and inclusive education reform, this reveals its relevance beyond the localized classroom context (Fitriyah, 2025). The success of experiential with collaborative teaching in this study offers a model of culturally adaptive, rights-based instruction that resonates with international goals for inclusive and equitable quality education, especially within specialized learning environments (Do, Hoang, Le, & Tran, 2020).

RECOMMENDATION

Based on the findings, it is recommended that teachers and schools integrate experiential, real-life problem-solving activities into mathematics education to enhance deaf learners' conceptual understanding. Mathematics curricula should prioritize visual, kinesthetic, and interactive methods over verbal instruction. Schools are encouraged to adopt co-teaching models involving special education and content teachers, while teacher training programs should include collaborative teaching strategies such as team, station, and parallel teaching. Teachers should receive specialized training in experiential learning and collaborative methods, including sign language proficiency and differentiated instruction. Additionally, curriculum policymakers should revise standards to incorporate these approaches, and schools should be equipped with appropriate visual aids, assistive technologies, and manipulatives to support effective experiential learning.

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