



**EXPLORING THE INSTRUCTIONAL TECHNIQUES
USED IN TEACHING NUMERACY SKILLS AMONG LEARNERS
WITH HI IN SELECTED PRIMARY SCHOOLS IN KENYA**

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Abstract:

The purpose of this study was to explore the instructional techniques used in teaching numeracy skills among learners with HI in four selected primary schools in the four counties: Nandi, Uasin Gishu, Elgeiyo Marakwet, and Trans Nzoia. The study was based on B.F. Skinner's 'black box' theory. The study used a correlational research design. The study was carried out in Nandi, Uasin Gishu, Elgeiyo Marakwet, and Trans Nzoia Counties. In each county, one primary school with learners with HI was selected, making a total of 4 selected primary schools. The target population comprised teachers and head teachers in selected primary schools. The study selected 4 primary schools with learners with Hearing Impairment (HI). The total population of the study was 65 respondents. The institutions were sampled through stratified sampling. The study used both quantitative and qualitative research instruments (questionnaires and an interview guide). Statistical Package for Social Sciences (SPSS) was used to process and organize the data. To process the gathered data, both descriptive and inferential statistics were used. Means and standard deviation were used to describe the acquired data using descriptive statistics. The qualitative data from the open-ended questions were categorised to create recurrent themes and presented verbatim and in narrative form. The study results revealed that the majority of the respondents were of the view that learners who have a hearing impairment require visual cues/ support in their learning to assist their understanding of content. Visual cues, such as written instructions, diagrams,

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charts, and videos, can be essential tools for learners with hearing impairment to comprehend and engage with instructional materials effectively. The study findings concluded that there was a statistically significant positive correlation between instructional techniques used and academic performance among learners with HI ($r=0.622$, $p<0.05$). The study recommended that primary schools in Kenya adopt a multi-modal approach to teaching numeracy skills for learners with hearing impairment.

Keywords: learners with hearing impairment, instructional techniques, mathematics, numeracy skills

1. Introduction

The importance of mathematics for survival has been acknowledged on a global scale, especially in the fields of science and technology (Winseck, 2019). In addition to this, the price of desktop and laptop computers has decreased, increasing access to computers as a result of the enormous advancements in computer hardware and software innovation (Alashhab *et al.*, 2021). It primarily focuses on the use of several instructional styles that help throughout the teaching and learning process to reduce abstract concepts. Globally, teachers in Turkey are complementing the conventional lecture with teaching methodologies that emphasize conceptual comprehension, active learning, and relevant applications (Philippe *et al.*, 2020). According to Özüdoğru (2022), learners of engineering mechanics who used mathematics were able to solve calculus-required problems more conceptually than those who learned using conventional teaching strategies like the lecture method, historical method, book and pencil exercises, and teacher-centered instruction that only focused on the procedures.

In the era of information development, multimedia technologies, and applications are perhaps some of the most intriguing inventions. The Internet and other innovations in communication and computing benefited and received support from them. Mutflu and Akgün (2019) investigated how Turkish students who struggle with math may improve their arithmetic skills by using computers. It was discovered that they had made a development in their understanding of place value and counting, and they might resolve addition problems. However, it was shown that second-grade students still had issues with addition, particularly when the numbers were presented side by side. It may be said that the study's use of computer-assisted training helped learners improve their speed and arithmetic abilities. It is encouraged to employ triple coding and models that assist lessen the stress on working memory when teaching students who have trouble understanding mathematics.

In Africa, Going digital at a remote Namibian primary school, Kathare (2020) looked at constructivist assistive technology in a mathematics classroom for the hearing impaired. The outcomes from the experiment and the interviews both support the idea that the constructivist digital assistive technology may have improved the student's mathematical ability. In Nigeria, The impact of computer-based training on the ability of

students with hearing impairment to learn was examined by Maureen and Ifeanyi (2019). Because they were not exposed to training that includes Computer-Based Instruction (CBI) in the instruction of the hearing impaired, the data showed that the majority of instructors of students who are deaf or hard of hearing had not properly equipped or engaged themselves with modern technology.

In Kenya, Kipkorir and Simatwa (2016) investigated the difficulties experienced by students with physical disabilities who were utilizing computer-based learning techniques to study mathematics. According to the study, students who received traditional instruction and those who received computer-based learning (CBL) scored significantly differently on their final exams. The motivation of students to learn mathematics is positively impacted by CBL approaches. The results demonstrated that the usage of CBL enhances learners' accomplishment in mathematical performance as well as their motivation. In Meru County, Kenya, Kathare (2020) performed research on the impact of instructional strategies on arithmetic students' academic performance. The study found that students with hearing impairment do better academically in mathematics when a variety of teaching techniques are used. The survey also discovered that teachers mostly communicate with students who have hearing difficulties via complete communication and sign language. The study found that students with hearing impairments who attend special schools do better academically in mathematics when there is good communication and access to learning and teaching tools.

One of the science-based core disciplines, mathematics has long been a part of the primary school curriculum and is essential to education (Orina, 2023). It is well known that most learners struggle with mathematics. The fact that most students consistently perform poorly in the subject serves as an illustration of this (Oloo & Nyongesa, 2024). Most experts agree that the poor performance may be explained by the fact that few students with hearing impairments achieve below average on their final exams. This could be the case because the curriculum's presentation to students who have hearing loss, as well as how it is taught and assessed, has not been changed. Learners with hearing impairment may have a variety of disabilities, making it challenging to choose a facility that adequately meets their educational needs. Thus, it was essential to establish the instructional techniques used in teaching numeracy skills among learners with HI in selected primary schools in Kenya.

1.1 Objective of the Study

To determine the instructional techniques used in teaching numeracy skills among learners with HI in selected primary schools in the four selected counties: Nandi, Uasin Gishu, Elgeiyo Marakwet, and Trans Nzoia in Kenya.

2. Literature Review

2.1 Theoretical Review

The study was guided by B.F. Skinner's 'black box' theory and programmed instruction. The perspective of B.F. Skinner's theory is founded on a definition of learning as an obvious modification in behavior (Skinner, 1990). The use of computers in education has the potential to lead to more complex designs. Computers may be designed to evaluate student input and adjust lessons to suit each student's level of proficiency. Computers now can offer instructional information and demand mastery of each step in a tutorial mode in ways that were not achievable with the first machines. The key to making the most of a computer's capabilities is the instructional designer's sensitivity to various student learning styles. Even more sophistication is made possible by simulation, which uses a computer to simulate a real-world scenario and allows for realistic responses to learner input. The right conditions may be provided by well-made intellectual games to hone essential problem-solving abilities.

The relevance of this theory lies in the fact that it equates computer instruction to the conditioning of a desired behavior and that the learning process is based on the principle of reinforcement and the stimulus-response schema is based on operant conditioning, whereby a completely new behavior is learned to a familiar stimulus (Rutherford, 2009). The learner clicks on the computer to produce the required behavior and produce the intended outcomes from the learning process, and the classroom is compared to the "black box". To do this, CBL must deliver a stimulus, provide feedback on the learner's reaction (to the stimulus), and reinforce desired responses. The behavior that has to be learned must be broken down into manageable pieces (computer tasks) and given to the learner. The computer may repeat a given notion several times depending on the learner's replies, which reinforces the desired behavior.

2.2 Empirical Studies and Knowledge Gaps

Every day, people make choices that affect their health and well-being. Poor numeracy skills are common and affect more people than only those with lower incomes or less education, just as low health literacy (of which numeracy is a subset). People may feel overwhelmed by factors that influence comprehension, such as emotional stress (perhaps from a recent diagnosis), a lack of time or confidence, strong demands on numeracy abilities, or just a hatred of arithmetic (Lechner *et al.*, 2021). In Indonesia, Rusyani *et al.* (2021) conducted a study to assess mathematics learning outcomes in students with hearing impairment, focusing on the concept of multiplication. The Team-Games-Tournament (TGT) method was employed in teaching multiplication to seven students at a Special School in Cimahi. The study comprised pretest, TGT-based learning sessions, and posttest stages. Results indicated a significant improvement in multiplication concept understanding using the TGT method.

Hidayat *et al.* (2020) implemented strategies for teaching Archimedes' law regarding floating, hovering, and sinking using an egg model among students with hearing impairment (SHI) at the Bandung Vocational School, Indonesia. Their single-subject design included pre-test and post-test evaluations on three SHI students. The study compared conventional lecture-based methods with a combination of experimental demonstrations supported by media. While conventional methods proved ineffective due to SHI students' auditory perception challenges, integrating experimental demonstrations with media effectively facilitated the understanding of complex subjects related to Archimedes' law among SHI students. Amjad and Shoaib (2024) investigated academic facilitators enabling undergraduate Students With Hearing Impairment (SWHI) to succeed in higher education in Pakistan. Their study, involving 30 SWHI undergraduates from a private institution, utilized SPSS-analyzed surveys in sign language. Findings highlighted significant engagement in academic activities, active listening, effective group work, and intrinsic academic motivation among SWHI students. However, challenges such as poor study skills were also evident, indicating the need for tailored support services to enhance SWHI students' educational experiences and outcomes.

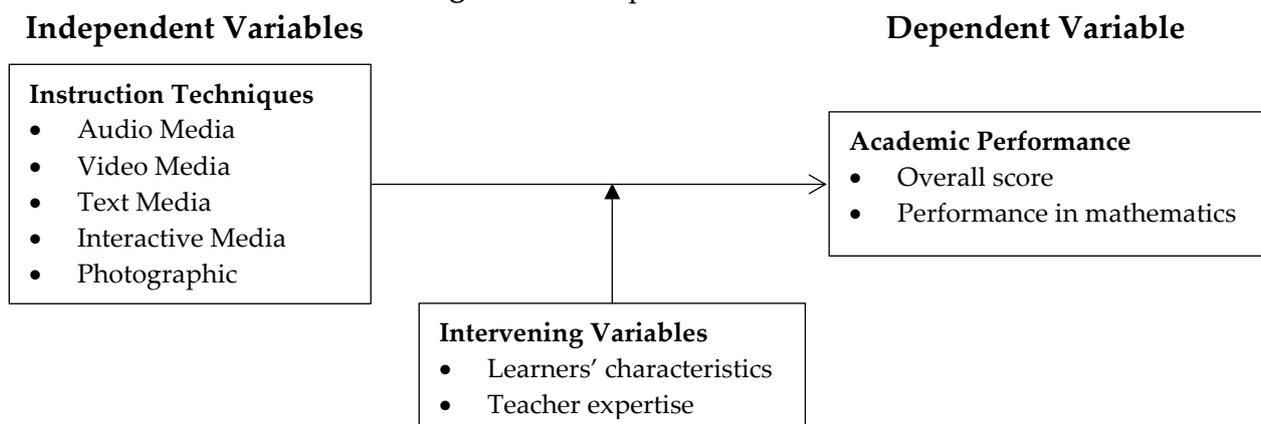
Roy *et al.* (2021) introduced a new Android app designed to enhance vocabulary and arithmetic skills in Indian Sign Language (ISL) among speech-impaired and hearing-impaired individuals in India. The app includes an ISL dictionary in 11 regional languages, focusing particularly on Bengali synonyms and antonyms explained through simple sentences. This technological intervention aims to improve linguistic and arithmetic proficiency concurrently, catering to the specific learning needs of HI individuals. Roy *et al.* (2021) developed an Android app to enhance vocabulary and arithmetic skills in Indian Sign Language (ISL) among speech-impaired and hearing-impaired individuals in India. In Nigeria, Onojah and Okoro (2023) assessed the availability and utilization of instructional materials for teaching mathematics to preschool children with hearing impairment in Oyo State. Their study, using the Instructional Materials for Teaching Preschool Children with Hearing Impairment Mathematics Questionnaire (IMTPCHIPQ), revealed significant gaps in both the availability and utilization of instructional materials among teachers in special public primary schools. Challenges such as inadequate materials and teacher knowledge of improvisation were identified as barriers hindering effective mathematics instruction for preschool children with hearing impairment.

Chalise (2024) discussed the perceptions of teachers in Kenya regarding numeracy skills and their universal applicability in problem-solving across different educational levels and life contexts. Teachers acknowledge numeracy skills as crucial for addressing various challenges, irrespective of mathematical proficiency or academic level. This underscores the importance of numeracy in everyday problem-solving scenarios, emphasizing its role in fostering practical and critical thinking abilities among learners. The study discussed the perceptions of teachers in Kenya regarding the importance of numeracy skills in problem-solving across different contexts. However, the study did not

empirically investigate the effectiveness of specific instructional techniques, such as computer-assisted instruction, in enhancing numeracy skills and academic performance among learners with hearing impairment. The present study seeks to fill this gap by exploring these relationships within the context of primary schools in Kenya, thereby providing empirical evidence on the impact of instructional strategies on academic outcomes for learners with hearing impairment.

2.3 Conceptual Framework

Figure 1: Conceptual framework



Source: Author's Conceptualization (2024).

3. Methodology

3.1 Study Locale

The study was conducted in Nandi, Uasin Gishu, Elgeiyo Marakwet, and Trans Nzoia Counties. The study was carried out in selected primary schools in Kenya. The selected primary schools were those that offer specialized education to learners with HI. In each county, one primary school with learners with HI was selected, making a total of 4 selected primary schools.

3.2 Research Design and Target Population

The study used a correlational research design, which entails measuring two variables and assessing the relationship between them, with no manipulation of an independent variable (Limberg *et al.*, 2021). A correlational research design investigates relationships between variables without the researcher controlling or manipulating any of them. The population under study comprised teachers and head teachers in selected primary schools. The study selected 4 primary schools with learners with HI. The total population of 65 respondents is depicted in Table 1.

Table 1: Target Population

County	Head Teachers	Teachers
Uasin Gishu County	1	13
Nandi County	1	17
Elgeiyo Marakwet County	1	19
Trans Nzoia County	1	12
Total	4	61

3.3 Sampling Techniques and Sample Size

Using stratified sampling, the institutions that were sampled were chosen. The sample frame can be segmented into various strata when the population being studied falls into several unique groups. Individual respondents are then chosen at random from each stratum's sampled independent sub-population (Limberg *et al.*, 2021). There is an equal chance that each respondent in a stratum was chosen. Consistent representation in the sample is ensured by using the same sampling fraction for each stratum. By stratification and altering sampling percentages between strata, the researcher can accurately reflect minority groupings of interest to them (Creswell & Plano Clark, 2016). The study used a census survey. Census is the study of every unit, everyone, or everything in a population. A census provides a true measure of the population with no sampling error, benchmark data may be obtained for future studies, and detailed information about small sub-groups within the population is more likely to be available. Since the population is small (65), the census was used to collect information from the entire population (Stratton, 2021).

3.4 Research Instruments

Data was collected through a questionnaire because of its benefits for data collection, including its general lack of interviewer bias, the large number of people who can be asked to participate, and the sense of anonymity that respondents may experience (Shatri, 2020). Closed-ended questions were created since they make data analysis simpler and more accurate (Agha *et al.*, 2021), allowing for a correct interpretation of the replies. Additionally, they facilitate comparisons, provide a high degree of impartiality, and lessen answer fabrication (Shatri, 2020). Additionally, open-ended questions would be employed, particularly for exceptional scores, since they allowed the researcher to go further into the research subject and provide rich information (Zou *et al.*, 2021).

3.5 Pilot Study

A pilot study was conducted with 7 participants from 2 selected schools who were not included in the main research. Two schools tested the questionnaires. Questionnaires were supplied to the chosen school teachers to complete. The answers to the questionnaires and interview times were gathered and carefully examined. The construct and content validity of the research tool were tested through expert judgment. The tools were given to seasoned professors who are authorities in the field of educational administration to assess the authenticity of the content. Cronbach's alpha was used to

test the reliability of the measures in the questionnaire (Peterson & Kim, 2013). A Cronbach's alpha of 0.781 was obtained indicating that the data was reliable.

3.6 Data Collection Procedures

The researcher sought approval from Kenyatta University to apply for a research permit from the National Commission for Science, Technology, and Innovation. The Director of Education from the four counties received a copy of the permission and was told of the study. Additionally, the head teachers of the schools that were sampled were contacted and informed of the study to acquire informed consent. The researcher then started gathering data. The questionnaire was sent by the researcher after choosing responders. The responders were given a questionnaire to complete, and it was chosen right away. The head teachers' convenience was taken into consideration while scheduling the 30-minute interviews. The researcher took notes during the conversation as it went on.

3.7 Data Analysis

Data cleansing came next to identify any missing, irrelevant, or inaccurate data for the objective of raising the quality. Errors and omissions were changed, replaced, or removed to make the data compatible with other sets that are comparable to it. Statistical Package for Social Sciences (SPSS) was used to process and organize the data. To process the gathered data, both descriptive and inferential statistics were used. Means and standard deviation were used to describe the acquired data using descriptive statistics. Second, to determine the relationship between variables, inferential statistics, namely Pearson Correlation, was used. Thirdly, the relationship between variables was predicted using multiple linear regressions.

4. Results and Discussions

Data obtained from the field were analyzed using descriptive statistics with the aid of the Statistical Package for Social Science (SPSS). The study's target population consisted of teachers and head teachers in selected primary schools. The study sampled 65 respondents and managed to collect data from 64 respondents (60 teachers and 4 head teachers). This represented a 98.5 percent response rate. This was affirmed by Saleh and Bista (2017), who noted that a response rate of more than 75% is appropriate for data analysis.

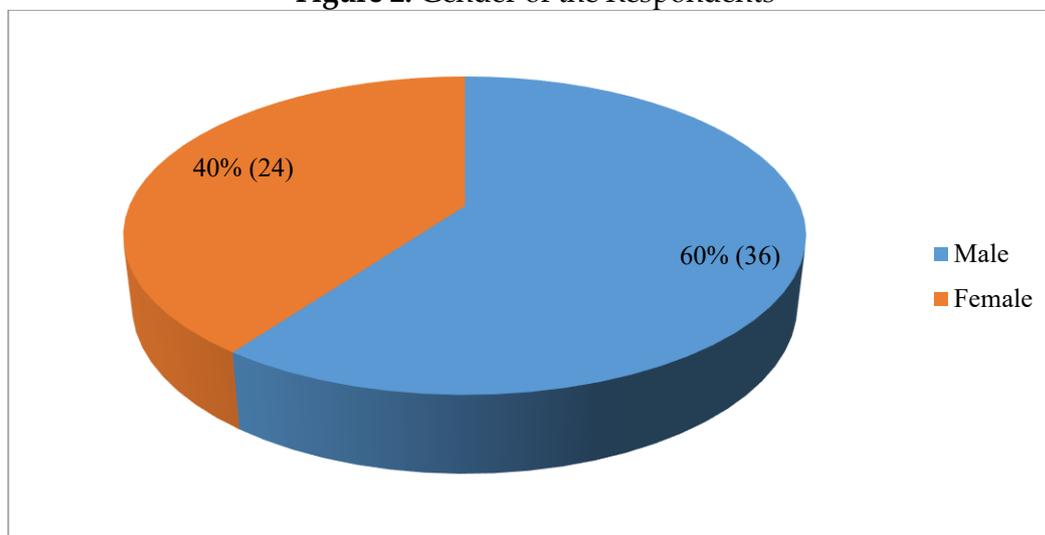
4.1 Background Information

The study sought to establish the general information of the respondents. The study sought to establish the gender, years of experience, and highest educational level of the respondents. The study results were as follows.

4.1.1 Distribution of Respondents by Gender

The study sought to establish the distribution of respondents by gender. These findings are shown in Figure 2.

Figure 2: Gender of the Respondents



The study findings on the gender of the respondents showed that 60.0% were male, while 40.0% were female. This shows that the study managed to collect data from both genders, and their opinions were represented in the study. This implies that the majority of the staff are male.

4.1.2 Distribution of Respondents by Age Brackets

The study sought to determine the distribution of respondents by age bracket, and the results are presented in Table 2.

Table 2: Age Bracket of the Respondents

Age Bracket	Frequency	Percent (%)
Less than 25 years	2	3.0
25-35 years	23	37.8
36-45 years	26	42.9
46-55 years	10	16.3
Total	60	100.0

The study results revealed that the majority of the respondents were aged 36-45 years, representing 26 (42.9%), 23 (37.8%) were aged between 25-35 years, 10 (16.3%) were aged 46-55 years, while 2 (3.0%) were aged less than 25 years. This implies that the study managed to collect data from all the age brackets captured in the study.

4.1.3 Distribution of Respondents by Level of Education

The study sought to determine the distribution of respondents by the highest level of education, and the results are presented in Table 3.

Table 3: Highest Level of Education of the Respondents

Educational Level	Frequency	Percent (%)
Undergraduate	36	60.2
Post-graduate	24	39.8
Total	60	100.0

The study findings on the education level of the respondents indicated that 36 (60.2%) were undergraduate degree holders, while 24 (39.8%) were postgraduate degree holders. This implies that the respondents were knowledgeable and therefore understood the study questions, and this could be interpreted to mean that they gave a true and fair view of the study questions.

4.1.4 Distribution of Respondents by Years of Work

The study sought to determine the distribution of respondents by the years of work, and the results are presented in Table 4.

Table 4: Years of work

Years of work	Frequency	Percent (%)
1-5 Years	6	10.8
6-10 Years	26	43.8
11-15 Years	28	45.4
Total	60	100

The study results on the age of the respondents indicated that 6 (10.8%) of the respondents had served for 1-5 years; 26 (43.8%) had served for 6-10 years, whereas 28 (45.4%) had served for 11-15 years. This implies that the majority of the respondents had served for 11-15 years and that the study collected data from all the age brackets represented in the study.

4.2 Instructional techniques used in teaching numeracy skills among learners with HI

The study sought to establish the effect of instructional techniques used in teaching numeracy skills on the academic performance of learners with HI. The study findings are presented in Table 5.

Table 5: Instructional Techniques Used in Teaching Numeracy Skills

Statements		SA	A	U	D	SD	Mean	Std. Dev
All learners benefit from captions especially those who are deaf or hearing-impaired, plus those with English as a second language.	F	17	26	9	6	3	3.85	0.147
	%	27.7	43.1	15	9.2	5		
Many classrooms are now equipped with technologies such as interactive whiteboards (IWBs) and sound-field amplification systems.	F	18	24	6	9	3	3.82	0.174
	%	30.8	40	9.8	14.4	5		
Learners who have a hearing impairment require visual cues/ support in their	F	15	35	9	1	0	3.97	0.342
	%	25	59	15	1	0		

learning to assist their understanding of content.								
There are always variables as to where a learner who has a hearing impairment should sit in the classroom.	F	28	16	9	4	2	3.01	0.346
	%	47	27	15	7	4		

The study findings revealed that 70.8% of the respondents agreed that all learners benefit from captions, especially those who are Deaf or hearing-impaired, plus those with English as a second language (Mean=3.85, SD=0.147), as compared to 14.2% who disagreed. The findings implied that the majority of the respondents agreed that captions benefit all learners, particularly those who are Deaf or hearing-impaired and those with English as a second language (ESL). This result corroborates the importance of visual supports in enhancing comprehension among students with hearing impairments, as noted by Rusyani *et al.* (2021). Their study highlighted the effectiveness of visual aids, akin to captions, in improving the understanding of mathematical concepts among students with hearing impairment. This finding is consistent with the broader literature that emphasizes the role of visual cues in facilitating learning for students with sensory disabilities (Roy *et al.*, 2021).

Similarly, a significant proportion (70.8%) of respondents acknowledged the presence of technologies such as Interactive Whiteboards (IWBs) and sound-field amplification systems in classrooms. This finding is supported by global trends where technological integration in classrooms is increasingly seen as beneficial for enhancing learning experiences among students with hearing impairment (Amjad & Shoaib, 2024). Amjad and Shoaib noted that technology aids academic engagement and interpersonal skills among students with hearing impairment, supporting the current study's findings on the prevalence and perceived benefits of classroom technologies. An overwhelming 84.0% of respondents agreed that learners with hearing impairment require visual cues to aid their understanding of content. This finding is in agreement with research by Hidayat *et al.* (2020) and Roy *et al.* (2021), which emphasize the necessity of visual aids in teaching abstract concepts to students with hearing impairment. Regarding seating arrangements, 74.0% of respondents acknowledged variability in where learners with hearing impairment should sit in classrooms. This finding reflects a practical consideration in inclusive education settings, where optimizing classroom seating can impact students' participation and learning experiences (Onojah & Okoro, 2023). The findings of the current study underscore the significance of adopting multi-modal instructional strategies that integrate visual supports and technologies to enhance numeracy skills among learners with hearing impairment. These findings are consistent with existing literature, which emphasizes the effectiveness of such approaches in improving academic outcomes and inclusivity in educational settings.

4.3 Inferential Statistics

Pearson correlation was used to measure the extent of correlation between variables of the study and to show the strength of the linear relationship between variables in the

correlation ranges between +1 and - 1, where $r > 0.7$ indicates a strong positive relationship, $r = 0.5$ and below 0.7 indicates a moderate relationship and where $r = 0.49$ and below indicates a weak relationship between study variables. Where $r = 0$ indicates that there is no relationship. The study further sought to test the following research hypothesis:

H₀₁: There is no relationship between instructional techniques used in teaching numeracy skills and academic performance among learners with HI in selected primary schools in Kenya.

The study findings are tabulated in Table 6.

Table 6: Relationship between Study Variables

		Instructional techniques used
Instructional techniques used	Pearson Correlation	1
	Sig. (2-tailed)	
Academic performance among learners with HI	Pearson Correlation	.622**
	Sig. (2-tailed)	0.000
	N	60

** . Correlation is significant at the 0.01 level (2-tailed).

The study findings indicated that there was a statistically significant positive correlation between instructional techniques used and academic performance among learners with hearing impairment ($r = 0.622$, $p < 0.05$). Thus, the null hypothesis: **H₀₁:** 'There is no relationship between instructional techniques used in teaching numeracy skills and academic performance among learners with HI in selected primary schools in Kenya' was rejected. This finding corroborates those of Rusyani *et al.* (2021), who similarly found that interactive teaching methods, such as the Team-Games-Tournament (TGT) approach, significantly improved learning outcomes among students with hearing impairment in Indonesia. The collaborative nature of instructional techniques appears pivotal in enhancing numeracy skills and academic performance in this population (Rusyani *et al.*, 2021). The use of CAI showed a significant positive correlation with academic performance among learners with hearing impairment ($r = 0.631$, $p < 0.05$). These findings are supported by Rogayan *et al.* (2021), whose study in the Philippines demonstrated that CAI effectively improved both motivation and academic performance in social studies among secondary school students. This aligns with the notion that technology-mediated learning can enhance educational outcomes by providing accessible and engaging learning opportunities tailored to specific learning needs (Rogayan *et al.*, 2021).

CAI had a statistically significant positive effect on academic performance among learners with hearing impairment ($r = 0.411$, $p < 0.05$). These findings agree with those of Adeniran and Daranijo (2023), who observed improved mathematics performance among students with hearing impairment in Nigeria when CAI was employed. The consistent positive impact of technology in enhancing academic achievement underscores its potential as a valuable tool in special education settings. By framing each

finding about existing literature, your study's conclusions are enriched with contextual insights and comparative perspectives. This approach not only validates your findings but also contributes to a deeper understanding of how instructional techniques and CAI can be effectively leveraged to support learners with hearing impairment in achieving academic success. It underscores the importance of adopting inclusive educational strategies that address the diverse learning needs of students with disabilities.

5. Conclusions

Based on the findings, it is logical that the instructional techniques used in teaching numeracy skills to learners with hearing impairment in selected primary schools in Kenya predominantly rely on visual cues and supports. The study concluded that there was a relationship between instructional techniques used in teaching numeracy skills and academic performance among learners with HI in selected primary schools in Kenya, which was rejected.

6. Recommendations

Based on the findings regarding instructional techniques, it is recommended that primary schools in Kenya adopt a multi-modal approach to teaching numeracy skills for learners with hearing impairment. This approach should prioritize the incorporation of visual cues and supports alongside traditional auditory methods. Additionally, educators should undergo training in utilizing diverse instructional techniques effectively to cater to the individual learning needs of learners with hearing impairment.

For further research, it is suggested to explore the long-term effectiveness and sustainability of computer-assisted instruction (CAI) in enhancing numeracy skills and academic performance among learners with hearing impairment in primary schools. Longitudinal studies could investigate the continued impact of CAI on students' numeracy proficiency and academic achievement over an extended period, tracking their progress and performance throughout their educational journey.

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Conflict of Interest Statement

The authors declare no conflicts of interest.

About the Author(s)

Pwokah Nekoye Evelyne is a highly experienced and dedicated Special Needs Educator with a strong professional commitment to inclusive learning and the advancement of education for learners with special needs, particularly those with hearing impairments. She brings extensive experience across higher education, special schools, and educational leadership, with a proven record of excellence in teaching, administration, curriculum development, and advocacy for inclusive education. Ms. Pwokah has served as a Lecturer in Special Needs Education at Kaimosi Friends University, where she contributed to teacher preparation and academic development in inclusive education. Her professional journey also includes teaching and leadership roles at St. Anthony School for the Deaf, Eldoret School for the Hearing Impaired, and Michael Wamalwa School for the Hearing Impaired, Kitale, where she served as Deputy Principal and later as Principal. In these roles, she demonstrated strong instructional leadership, effective school management, and the successful implementation of inclusive classroom practices. Beyond formal school settings, Ms. Pwokah has made significant contributions to alternative learning environments and national education initiatives. She has worked with the Kenya Institute of Curriculum Development (KICD) as a panelist, supporting curriculum review and the adaptation of learning and teaching materials for learners with special needs, with a focus on digital content development. She has also provided mentorship to newly trained teachers and led professional development initiatives in inclusive education and curriculum design, earning recognition for her leadership and national advocacy in inclusive classroom practices. Academically, Ms. Pwokah holds a Master's degree in Special Needs Education, specializing in Hearing Impairment and Inclusive Education, and a Bachelor's degree in Special Needs Education, both from Kenyatta University, Kenya. She is currently a PhD continuing student pursuing a Doctor of Philosophy in Special Needs Education at the School of Education and Lifelong Learning, Kenyatta University. Her doctoral research focuses on *Computer-Assisted Instruction in Promoting Numeracy Skills among Learners with Hearing Impairments in Kenya*. Her academic and

research interests include inclusive education practices, hearing impairment and deaf education, computer-assisted instruction and educational technology, digital and adaptive learning content development, numeracy and literacy skills acquisition among learners with special needs, learner–teacher interaction processes, curriculum design and implementation, alternative learning environments, and teacher professional development in special needs education. Ms. Pwokah demonstrates strong multilingual proficiency in English, Kiswahili, her mother tongue, and Kenyan Sign Language, enabling effective engagement across diverse educational contexts. In recognition of her expertise and international outlook, she was appointed as a Partner Teacher at Westhaven Elementary School, Portsmouth Public School, Virginia, for the 2025–2026 academic year. Overall, Ms. Pwokah Nekoye Evelyne is a respected educator, academic, researcher, and advocate whose work continues to make significant contributions to inclusive education, digital learning innovation, and the empowerment of learners with hearing impairments at both national and international levels.

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References

- Adeniran, T. A., & Daranijo, S. B. (2023). The Use of Computer in Teaching and Learning Mathematics to Hearing Impaired Students in Special School in Oyo East Local Government Area of Oyo State. *Rethinking the Teaching and Learning of Mathematics in the Pandemic Era*, 245. Retrieved from <https://www.researchgate.net/profile/Kamoru-k-USman/publication/374447272>
- Alashhab, Z. R., Anbar, M., Singh, M. M., Leau, Y. B., Al-Sai, Z. A., & Alhayja'a, S. A. (2021). Impact of the coronavirus pandemic crisis on technologies and cloud computing applications. *Journal of Electronic Science and Technology*, 19(1). Retrieved from <https://www.sciencedirect.com/science/article/pii/S1674862X20300665>
- Amjad, F., & Shoaib, A. (2024). Academic Enablers to the Success of Students with Hearing Impairment at the Undergraduate Level. *Pakistan Social Sciences Review*, 8(2), 298-310. Retrieved from <https://www.ojs.pssr.org.pk/journal/article/download/546/403>
- Chalise, K. (2024). *Perceptions of Teachers toward Inclusive Education with a Focus on Hearing Impairment: A Quantitative Study* (Doctoral dissertation, Kathmandu University School of Education). Retrieved from http://elibrary.ku.edu.np:8080/bitstream/20.500.14301/396/1/WCC_Kiran%20Chalise%20123.pdf

- Creswell, J. W., & Plano Clark, V. L. (2023). Revisiting mixed methods research designs twenty years later. *Handbook of mixed methods research designs*, 1(1), 21-36. Retrieved from <https://www.torrossa.com/gs/resourceProxy?an=5730651&publisher=FZ7200#page=56>
- Hidayat, D. S., Rahmat, C., Fattah, N., Rochyadi, E., Nandiyanto, A., & Maryanti, R. (2020). Understanding Archimedes' law: What are the best teaching strategies for vocational high school students with hearing impairment? *Journal of Technical Education and Training*, 12(1). Retrieved from <https://publisher.uthm.edu.my/ojs/index.php/JTET/article/download/5399/3535>
- Kathare, N. M. (2020). Effect of teaching methods on academic performance in mathematics among learners with hearing impairment in Meru County, Kenya. *Unpublished Doctoral dissertation, Kenyatta University*. Kenya. Retrieved from <https://ir-library.ku.ac.ke/bitstream/123456789/21324/1/Effect%20of%20teaching%20methods%20on%20academic...pdf>
- Kipkorir, R. N., & Simatwa, E. (2016). Challenges Faced By Learners With Physical Handicaps In Learning Mathematics Using Computer-Based Learning Methods In Kenya. Retrieved from <http://ir-library.mmarau.ac.ke:8080/handle/123456789/6771>
- Lechner, C. M., Gauly, B., Miyamoto, A., & Wicht, A. (2021). Stability and change in adults' literacy and numeracy skills: Evidence from two large-scale panel studies. *Personality and Individual Differences*, 180. Retrieved from <https://scholar.google.com/citations?user=JFN1Y1YAAAAJ&hl=en&oi=sra>
- Limberg, D., Gnilka, P. B., & Broda, M. (2021). Advancing the counseling profession by examining relationships between variables. *Journal of Counseling & Development*, 99(2), 145-155. Retrieved from <https://scholar.google.com/citations?user=Fw2ff8IAAAAAJ&hl=en&oi=sra>
- Maureen, N. N., & Ifeanyi, a (2019). Effects of Computer-Assisted Instruction (CAI) On Achievement and Retention of Learners with Hearing Impairment in Computer Studies. *IOSR Journal of Research & Method in Education (IOSR-JRME)* 9(5). Retrieved from <https://www.iosrjournals.org/iosr-jrme/papers/Vol-9%20Issue-5/Series-1/D0905012437.pdf>
- Mutflu, Y., & Akgün, L. (2019). Using Computer for Developing Arithmetical Skills of Students with Mathematics Learning Difficulties. *International Journal of Research in Education and Science*, 5(1), 237-251. Retrieved from <https://files.eric.ed.gov/fulltext/EJ1198106.pdf>
- Oloo, J. A., & Nyongesa, C. M. (2024). Strategies and interventions employed by teachers in supporting students with mathematics learning difficulties in Kenya. *Research in Mathematics Education*, 1-20. <https://doi.org/10.1080/14794802.2024.2339811>
- Onojah, D. M., & Okoro, E. N. (2023). Assessment of Availability and Utilization of Instructional Materials for Teaching Preschool Children with Hearing Impairment

- Mathematics in Oyo State, Nigeria. *African Journal of Humanities and Contemporary Education Research*, 10(1). Retrieved from <https://publications.afropolitanjournals.com/index.php/ajhcer/article/download/442/332>
- Orina, W. A. (2022). *Preparedness in the Implementation of Competency-based Curriculum in Science Learning Areas in Public Primary Schools in Nairobi County, Kenya* (Doctoral dissertation). The Catholic University of Eastern Africa.
- Özüdoğru, F. (2022). Investigating the effect of differentiated instruction on academic achievement and self-directed learning readiness in an online teaching profession course. *ie: inquiry in education*, 14(2), 2. Retrieved from <https://philpapers.org/archive/EVAESP.pdf>
- Peterson, R. A., Kim, Y., & Choi, B. (2020). A meta-analysis of construct reliability indices and measurement model fit metrics. *Methodology*, 16(3), 208-223. Retrieved from <https://meth.psychopen.eu/index.php/meth/article/download/2797/2797.pdf>
- Philippe, S., Souchet, A. D., Lameris, P., Petridis, P., Caporal, J., Coldeboeuf, G., & Duzan, H. (2020). Multimodal teaching, learning and training in virtual reality: a review and case study. *Virtual Reality & Intelligent Hardware*, 2(5), 421-442. Retrieved from <https://www.sciencedirect.com/science/article/pii/S2096579620300711/pdf?md5=c7cab2e905af23ad7035aac9a63503da&pid=1-s2.0-S2096579620300711-main.pdf>
- Roy, S., Maiti, A. K., Basak, G. K., & Ghosh, K. (2021). Difficulty with language comprehension and arithmetic word problems due to hearing impairment: Analysis and a possible remedy through a new Android-based assistive technology. In *Data Analytics in Biomedical Engineering and Healthcare* (pp. 29-56). Academic Press. Retrieved from <https://www.sciencedirect.com/science/article/pii/B9780128193143000033>
- Rusyani, E., Saepulloh, A., Maryanti, R., Ragadhita, R., & Al Husaeni, D. F. (2021). The effect of the team-games-tournament method on improving the learning ability of student with hearing impairment in multiplication concepts. *Indonesian Journal of Multidisciplinary Research*, 1(2), 219-228. Retrieved from <https://ejournal.upi.edu/index.php/IJOMR/article/download/37132/15850>
- Rutherford, A. (2009). *Beyond the box: B. F. Skinner's technology of behavior from laboratory to life, 1950s-1970s*. Toronto, Ontario, Canada: University of Toronto Press.
- Shatri, Z. G. (2020). Advantages and disadvantages of using information technology in learning process of students. *Journal of Turkish Science Education*, 17(3), 420-428. Retrieved from <https://mail.tused.org/index.php/tused/article/download/1099/633>
- Winseck, D. (2019). Internet infrastructure and the persistent myth of US hegemony. In *Information, technology and control in a changing world: Understanding power structures in the 21st century* (pp. 93-120). Cham: Springer International Publishing. <https://openresearch-repository.anu.edu.au/bitstreams/b5cc370f-c161-44cb-b285-3f90e50e9e5b/download#page=105>

Zou, W., Hu, X., Pan, Z., Li, C., Cai, Y., & Liu, M. (2021). Exploring the relationship between social presence and learners' prestige in MOOC discussion forums using automated content analysis and social network analysis. *Computers in Human Behavior*, 115. Retrieved from <https://www.sciencedirect.com/science/article/pii/S0747563220303290>