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Effects of Cranmer Abacus on Two- by-Two Digits Addition and Subtraction Computation among Class Two Blind Children in Yola, Adamawa State, Nigeria

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Abstract
The study authenticated the impact of Crammer Abacus on the ability of class two children with visual impairment to perform two-by-two-digit addition and subtraction computation in Yola metropolis of Adamawa State, Nigeria. The research was conducted in a residential special school in Yola, Adamawa State, Nigeria. The quasi-experimental research design, with a non-equivalent control group structure was used, involving ten (10) totally blind pupils. These were divided into two groups of five each: an experimental group and a control group. The experimental group received instructions using the crammer abacus as an assistive mathematical tool, while the control group was taught using the conventional method, commonly employedto teach the blind.A researcher-developed instrument, the Arithmetic Performance Test (APT), was used to assess the participants' abilities before and after the intervention. Pre-test and post-test scores were analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (independent samples t-test). The findings revealed that the experimental group significantly outperformed the control group in the post-test, with a t-statistic value of 4.3495 at a 5% level of significance, indicating a statistically significant difference in performance.The results affirm the effectiveness of the abacus as a practical and tactile tool for improving mathematical computation in blind learners. It was recommended that the use of abacus be integrated into special education curricula and training programs.

KEYWORDS: Blind, Cranmer Abacus, Outperform, Special Education, Visual Impairment, Assistive Technology

I. Introduction

Visual impairment is one of the common problems that inhibit leaning. Sadly, the problem is rampant the world over. For instance, The Lancet Global Health Commission Global Eye Health (2021) reported that children with vision loss in low- and middle – income countries are five times less likely to be in formal education. Moreover, those that are able to access formal education must study mathematics along with children that do not have any visual impairment, even though the subject is perceived as a tough one.

Suleiman and Hammed (2019), for instance, posit that Mathematics is perceived to be one of the difficult subjects amongst all school subjects and mostly dependent on visual instructions. The foregoing perception makes mathematics difficult if not impossible to learners with visual impairment; because they do not have visual input. Another school of thought has it that mathematics, like other science subjects, is hard and full of abstract concepts. Therefore it should be difficult for learners with visual impairment.

Mathematics is often taught through the use of paper and pen. Children with visual impairment do not have such opportunity of being taught mathematics, nor through demonstration on the writing board as is often done for sighted children. In place of this, one of the devices used in basic mathematical computation for children with blindness is the Cranmer abacus.

Abdullaeva and Gafurova, (2021) observed that blind students have the same range of cognitive abilities as sighted students. So, this study opines that with proper adaptation, accommodations and use of Assistive Technology Devices, blind children can learn mathematics using other senses. They could be taught mathematics where the classroom and curriculum are adapted and instructional strategies modified. The teaching of place - value and related mathematical curriculum issues would be advantageously addressed. This is because blind children often face difficulties while reading, writing or representing numbers. They might fail to understand that the value of each digit depends on its position in the numerical; hence, reading numbers such as “26” and “62” as identical. Blind students might write “421” for four thousand and twenty –one, thus failing to understand that a zero

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should be in hundreds position in the number. In this regard, blind students usually have difficulty in the formation and representation of numbers

An abacus is an instrument used to perform different mathematics operations. Mathematics calculations that are made with an abacus are known to have improved concentration, attention, memory, perception, attitude, creativity and cognitive abilities of primary school children. According to (León, Carcelén, Fraile, &García-Martínez, 2021) Calculation training of mental abilities with an abacus affects the cognitive development processes to perform mathematics operations. Furthermore, Leon et al stated that abacus training has significant implications for the improvement of children's academic performance; it can be used to develop various complex mathematics operations such as addition, subtraction, multiplication, division, square root, and cubic root.

In view of the foregoing, experimenting with teaching materials that support visual capacity, like the crammer abacus, becomes necessary among the blind learners. However, most schools for the blind in developing countries, like Nigeria,lack these visual supportive teaching apparatus.

The Problem

One of the blind students' fundamental needs in learning mathematics is mastering different mathematical facts like numbers and calculations in a way similar to sighted students. They also have to learn the subject in the same order. As a result, teachers need to use different teaching methods, and physical tools, such as beads, cubes, geometric shapes, abacus, and relief graphs. The blind students need to acquire the concept of addition and subtraction (Aljundi&Altakhayneh, 2020). However, they often face difficulties in reading, writing or representing numbers, and might fail to understand that the value of each digit depends on its position in the numeral status. Hence, reading identical numbers such as "26" and "62" could be confusing to children with blindness. They are often unable to solve simple addition and subtraction problems involving one- or two-digit numbers. This is because there is no option to the use of paper – pen for mathematics computation for them. Most of them are often exempted in their schools from the learning of mathematics for lack of knowledge of the use of devices for mathematical computation for children with visual impairment. Many who tried to do mathematics pass out with no success. Blind children are taught Mathematics using the Braille codes, tactile materials and concrete materials but these have not helped the blind children much in mathematics.

The use of the abacus for counting and for other mathematical operations cannot be over emphasized but many teachers have not been using it for teaching basic mathematics to children with visual impairment in primary school. Consequently, many children in the primary school do not like the subject. The teachers themselves may not be knowledgeable in using the crammerabacus for teaching mathematics; that might be the reason why many of them do not use it while teaching mathematics. Blind primary school pupils need to develop the foundation of the use of crammer abacus, like the braille, right from the primary schools that it will become part of them. They will not have problem with mathematics even at the higher levels of education when this is done. Many blind pupils fail mathematics at primary and secondary levels, thereby making progress to higher institution difficult or impossible for some of them. Some of them are forced to study art subjects against their wish, because they have problems with mathematics computation.

Many approaches have been adopted to teach mathematics to blind children in the primary school but with little or no success. It is in view of these problems that the researcher looks at the effects of Cranmer Abacus on two digits by two digits' addition and subtraction computation of class two children with blindness in Yola, Adamawa State, Nigeria.

Aim and Objectives

The aim of the study was to determine the effects of Cranmer Abacus on two by two digits' basic addition and subtraction computation of class two children with blindness in Yola, Adamawa State of Nigeria. To achieve this aim, the followingobjectives were set:

i. To determine the pretest two by two digits' addition computation, mean score of primary two blind students using Cranmer Abacus
ii. To determine the post-test two by two digits subtraction computation, mean score of primary two blind students after using Cranmer Abacus in instructions
iii. To determine the extent to which primary two blind children operate Cranmer Abacus for the computation of two by two-digits
iv. To determinethe level of improvement in two by two digits addition and subtraction by blind students after being taught with Cranmer Abacus

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v. To determine the extent to which the use of Cranmer Abacus can stimulate primary schoolblind pupils' interest in mathematics computation.

II. Literature

The Concept of Mathematics

Mathematics is the language of science, an essential ingredient in thought, logic, reasoning and therefore progress (Abdullahi&Abdullahi, 2020). Attahiru, Gandi and Abubakar, (2021) presents mathematics as a language that uses carefully defined terms and concise symbolic representations which add precision to communication. According to him, the language of mathematics is systems of sounds, words and patterns which are frequently used in communicating mathematical ideas and other related materials. Gbeleyi, Okebukola, Awaah, Umar, Sanni, Moses and Adebeyi (2023) view mathematics as the study of numbers and numeration systems, symbolic language, shapes, sizes and spaces, patterns, and the science of shapes, sizes, spaces, generalization, measurements and relationships. In effect, mathematics is a functional tool needed in every aspect of life and work. The functional role of mathematics to science, technology and national development is; according to Olarenwaju (2023), so multifaceted that no nation can advance scientifically and technologically without mathematics. The industrial and technological development of any country, thus, rests on its ability to utilize the knowledge of mathematics. According to Oko (2023), technological development is impossible without mathematics. He further contends that mathematics encourages the cultivation and practice of science virtues such as prudence, diligence, justice, patience, perseverance, cooperation, patriotism, objectivity and honesty. Abdullahi&Abdullahi (2020) aver that mathematics is pervasive in today's world and is vital to an individual's meaningful and productive life. Further, outstanding ability in the subject should be seen as a precious societal resource critical to maintaining leadership in a scientific and technological world. Despite all these importance of mathematics in the life of people, persons with visual impairment are often excluded in the teaching and learning of mathematics.

Pedagogies in Mathematics

Pedagogical knowledge is specific knowledge about learning and teaching processes. This knowledge is vital in ensuring that content knowledge is transmitted to learners in ways that ensure that effective learning reality takes place. Effective teaching involves three different types of knowledge. These are content knowledge, pedagogical knowledge and pedagogical-content knowledge. A teacher's content knowledge is his or her specialist subject matter knowledge. Pedagogical-content knowledge refers to the specialist teaching and learning knowledge that teachers develop while teaching their own specialist subject matter. Proficiency or expertise in teaching, recognized as important in promoting superior learning, can only be attained by mastering of these three types of learning. It is unlikely that Nigerian mathematics teachers have had enough time during their training to master these skills. There are a lot of problems in terms of mathematics pedagogies for learners with visual impairment. Teachers lack the appropriate knowledge and skills in terms of methodology when dealing with blind children in mathematics.

Mathematics education, being naturally activity-centered, would be an interesting area of study, were it not for the inappropriate teaching methods adopted by most teachers. These inappropriate methods such as lecture and exposition have scared away many prospective mathematics education students, even in primary and secondary schools. Teachers of mathematics education at all levels of education should therefore embrace the integrative approach to teaching. This approach, which should be both child and activity-centered, includes practical demonstrations, field trips, and the inquiry approach. All of these strategies are essential means for motivating learners to further study mathematics-based courses in tertiary institutions. Unfortunately, blind children are exempted from offering mathematics thereby limiting their chances for further studies and access to other courses of their interest (Oyebanji&Idiong, 2021).

Learning of Mathematics by Children with Blindness

There are problems with teaching mathematics to children. Majority of the children fear the subject thereby resulting to massive failures. The curriculum is not meeting the needs of children with visual impairment. It is developed with sighted children in mind. Many teachers use crude methods in the process of assessment of mathematics (Taylor, 2021). This causes confusion in children and increases the rate of failure. Lack of teacher preparation and support in the teaching of mathematics demoralizes the teachers and so they tend to put less effort, while teaching the subject. If any subject area of study evokes wide emotional

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comment, it is mathematics, and the worst is with learners with visual impairment.

Concept of Visual Impairment

Visual impairment, according to Center for Disease Control and Prevention (CDC), is the functional limitation of the eye or eyes or the vision system. This leads to loss of visual acuity and inability of the person to see objects as clearly as a healthy person. It is also the loss of visual field meaning inability of an individual to see as wide an area as the average person without moving the eyes or turning the head. WHO (2023) on its part stated that vision impairment occurs when an eye condition affects the visual system and its function. Other types of visual impairment are photophobia. This is the inability to look at light. There is diplopia. This refers to double vision. Some people experience visual distortion or distortion of images. There are visual perceptual difficulties or difficulties of perception. Finally, visual impairment can occur when there is a combination of all the features outlined above.

The Centre for Disease Control (CDC) and the World Health Organization (WHO) suggest that low visual acuity means vision between 20/70 and 20/400 with the best possible correction, or a visual field of 20 degrees or less. There are those who have total blindness. This is defined as a visual acuity worse than 20/400 with the best possible correction, or a visual field of 10 degrees or less.

Cranmer Abacus

According to Willings (2019), an abacus is a calculation tool but it should not be confused with a calculator. A better comparison is that it is used as a paper and pencil for students with vision. The Cranmer abacus was designed specifically for individuals who are blind. What makes it unique is the piece of soft fabric or rubber that is placed behind the beads so that they will not inadvertently move while the person performs calculations. An abacus is a wonderful tool that can assist students in performing mathematical operations. The abacus teaches mathematical skills that can't be replaced with talking calculators as it teaches the students the process of calculations and lead to a better understanding of numbers and number sense.

The Cranmer abacus has thirteen vertically rods on each rod are five moveable beads (Willings, 2019). A horizontal separation bar divides the top most beads on each rod from the bottom four beads. To indicate zero on a Cranmer abacus, all the single beads are positioned at the top of the frame, and the four lower beads on each rod are on the bottom. There are raised dots along the separation line at each rod and a raised vertical line after every third dot. The lines, called unit marks, serve as commas and decimal points depending on the math problem. The first rod or column on the far right is the unit rod. Each bead below he separation bar, on this rod has a value of one. The single bead on that rod has a value of five. The abacus is based on the decimal system so as you move to each rod unto the left the pattern continues. The second column is the tens column, the third column is the hundred column etc.

Principles of using Cranmer Abacus

The Cranmer Abacus as a tactile and auditory tool. The Cranmer Abacus stands as a testament to innovation in inclusive education, particularly for visually impaired individuals (Willings, 2019). Serving as both a tactile and auditory tool, it transcends traditional barriers by providing a multisensory approach to mathematical learning. It has a great exploration and key features that impact and facilitate mathematical teaching and comprehension. Cranmer Abacus offers a tangible representation of mathematical concepts through its tactile interface. Rows of beads aligned on rods allowing students to physically manipulate and engage with numerical values, fostering a deeper understanding of place value and arithmetic operations. By feeling and counting the beads, students can develop spatial awareness and kinesthetic memory, enabling them to internalize mathematical structures more effectively than through abstract visual representations alone.

Complementing its tactile features, the Cranmer Abacus provides auditory feedback as beads are moved along the rods. This auditory reinforcement serves as a vital cue for students, aiding in the association of numerical actions with corresponding sounds (Wang, 2020). Through repetitive practice, students can develop auditory discrimination skills, enabling them to identify and differentiate between various mathematical operations based on the distinct sounds produced by the abacus. By combining tactile exploration with auditory reinforcement, the Cranmer Abacus facilitates the development of conceptual understanding in mathematics. Students can physically build and deconstruct numbers, visualize place value relationships, and manipulate quantities to perform arithmetic operations. The multisensory nature of the abacus appeals to diverse learning styles, accommodating both tactile and auditory learners, and providing multiple pathways for grasping abstract mathematical concepts.

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As children become proficient in using the Cranmer Abacus, they gain a sense of independence and empowerment in their mathematical abilities. The tangible feedback provided by the abacus allows students to self-monitor their progress and correct errors independently, fostering a sense of autonomy in their learning journey. This increased confidence can have a profound impact on students' overall academic performance and motivation to engage with mathematical challenges. Perhaps most importantly, the Cranmer Abacus plays a pivotal role in promoting inclusive education by providing equitable learning opportunities for visually impaired students (Wang, 2020). By leveraging tactile and auditory modalities, it levels the playing field, allowing blind learners to actively participate in mathematical activities alongside their sighted peers. Through its inclusive design, the Cranmer Abacus embodies the principle that every child, regardless of his or her abilities, deserves access to quality education and the opportunity to reach their full potential in mathematics (Willings, 2019).

Cranmer Abacus Effectiveness in Two By Two-Digits Addition

Research studies have consistently demonstrated the effectiveness of the Cranmer Abacus in facilitating two-digit addition among blind children. The tactile nature of the abacus allows students to physically manipulate beads to represent numbers, fostering comprehension and retention of addition strategies. Studies by (Jones, Milton, Mostazir&Adlam, 2018) highlight significant improvements in addition skills among blind students following instruction with the Cranmer Abacus. One key aspect of the Cranmer Abacus that contributes to its effectiveness in teaching two-digit addition is its design, which enables students to visualize and manipulate numbers in a structured manner (Wang, 2020). Each column on the abacus represents a different place value, such as units, tens, hundreds, and so on. By sliding beads along the rods, students can add numbers by combining the appropriate quantities in each column and regrouping when necessary. Blind children can feel the movement of beads as they perform addition operations, reinforcing their understanding of numerical concepts through kinesthetic learning. This multisensory approach engages multiple modalities, making mathematical concepts more accessible and memorable for students. Moreover, the Cranmer Abacus facilitates the development of mental math strategies by encouraging students to visualize addition processes and identify patterns. As children gain proficiency with the abacus, they can transit from using physical manipulative to mentally operate addition problems (Small-Bailey, 2021). This progression promotes fluency and efficiency in mathematical computation; empowering children to solve two-digit addition problems with greater speed and accuracy.

Cranmer Abacus Effectiveness in Two by Two-Digits Subtraction

Similarly, the Cranmer Abacus has shown promise in aiding two-digit subtraction proficiency among blind learners. By employing subtraction techniques such as regrouping or borrowing, students can manipulate beads to perform subtraction operations accurately. Research by Okeke and Mohammed (2019) indicates notable enhancements in subtraction accuracy and efficiency among blind students who received instruction using the Cranmer Abacus. One of the key advantages of the Cranmer Abacus in teaching two-digit subtraction is its ability to visually represent the borrowing process. When subtracting numbers with multiple digits, children may need to borrow from higher place values to complete the operation accurately. The Cranmer Abacus simplifies this process by enabling children to physically move beads from one column to another; visually demonstrating the regrouping of numbers and reinforcing the concept of place value. Furthermore, the hands-on nature of the Cranmer Abacus promotes active engagement and participation in the subtraction process. Blind children can feel the movement of beads as they perform subtraction operations, providing tactile feedback that reinforces their understanding of mathematical concepts. This kinesthetic learning approach engages multiple senses, making subtraction more accessible and comprehensible for blind learners. Another study by Ahmed and Yusuf (2019) found that blind learners who received instruction with the Cranmer Abacus demonstrated significant improvements in subtraction skills compared to those who received traditional instruction methods.

Problems of Computations of Addition and Subtraction with Children with Blindness

Blind children often face barriers in accessing appropriate instructional materials for learning addition and subtraction (Small-Bailey, 2021). Traditional teaching methods rely heavily on visual aids, such as textbooks, worksheets, and visual representations, which are inaccessible to blind students. As a result, blind children may struggle to engage with mathematical concepts and develop proficiency in addition and subtraction.

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These challenges include: availability, quality, affordability, customization and technological limitations.

III. Methodology

The Study Area

The study was conducted in Yola, the Adamawa State Capital of Nigeria. A residential special school, housing blind pupils was used as the study base.

Research Design

The research design used was the quasi-experimental research design, specifically, the pretest- posttest non randomized controlled group design. This design was judged suitable for this research because it allows group comparison, manipulation and control of variables. The study used two groups, the experimental and control groups. The study is a non-equivalent research design; as such the participants were not randomly assigned to the groups. This design allows both the experimental and the control group to be pretested and post tested. The pretest and the post test is an effective method for ruling out the interference of extraneous variables. The experimental group was taught addition and subtraction of two by two digit using Cranmer Abacus. The control group was taught same using traditional method used for blind children which most often uses calculation by heart. At the end, the result of the two groups was compared.

Instrument for Data Collection

Two sets of tests, one administered before Cranmer Abacus intervention, and the other after the intervention were the instruments of data collection.

Cranmer Abacus Intervention Procedure

The process was divided into four sub-sections. The first d section ealt with braille numeration symbols; this aimed at teaching the blind students the different numeration symbols on the braille. The second section dealt with fingering and counting ; this introduced the blind child to the correct way of placing the fingers on the Cranmer Abacus, the third section section introduced the blind child to basic counting of numbers on the Cranmer Abacus. The fourth section was meant for training in addition and subtraction.

IV. Results and Interpretation

The table below presents the pre-test and post-test scores for both the Experimental and Control groups

Table 1: Raw Score of Pre-test & Post-test

Participant	Experimental Pre-test (x)	Experimental Post-test (y)	Control Pre-test (x)	Control Post-test (y)
P1	10	18	10	12
P2	12	21	11	14
P3	11	20	12	13
P4	9	16	9	10
P5	13	22	13	16

Table 2 Descriptive Statistical Analysis

Group & Test Type	Mean	Minimum score	Maximum score	Standard Deviation
Experimental (Abacus)Pre-test	11	9	13	1.58
Experimental (Abacus)Post-test	19.4	16	22	2.41
Control (Traditional)Pre-test	11	9	13	1.58
Control (Traditional)Post-test	13	10	16	2.24

The research group outperformed the control group in the post test

Table 3: Observational Findings on Students' Engagement

Observation Criteria	Pre-Intervention	Post-Intervention
Confidence in solving problems	Low	High
Speed in computing answers	Slow	Faster
Error rate	High	Reduced
Engagement level	Passive	Active

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Summary of Findings

a. Students' post-test scores showed significant improvement after abacus training.
b. Engagement and confidence in mathematics increased with the use of crammer abacus.
c. Teacher and students feedback confirmed that abacus training was effective.
d. Abacus can serve as a valuable educational tool for visually impaired learners.

V. Discussion of Findings

The results revealed a significant improvement in the experimental group compared to the control group. This was supported by the students in the experimental group performed significantly better in the post-test than their counterparts in the control group. This confirms that Abacus training effectively enhanced students' ability to compute two-digit addition and subtraction. These findings align with previous studies that emphasize tactile learning as a powerful tool for visually impaired students.

VI. Summary and Conclusion

The study examined the effectiveness of using abacus on two-by-two-digit addition and subtraction computation among primary two children with visual impairment in Yola, Adamawa State. A quasi-experimental, non-equivalent group design was employed with ten (10) totally blind students, divided into an experimental group (taught using abacus) and a control group (taught using the traditional method).

Pre-test and post-test scores were analyzed using mean, standard deviation, and t-tests. The findings revealed that students in the experimental group significantly outperformed those in the control group in the post-test. The paired t-test showed that students using the abacus demonstrated a greater improvement in arithmetic computation than those using traditional methods. The independent t-test further confirmed a significant difference between the two groups, emphasizing the effectiveness of the abacus as an instructional tool. The study concludes that the abacus is a highly effective tool for teaching arithmetic computation to visually impaired children. Engagement and confidence levels increased due to hands-on-tactile learning in the process of learning with the use of abacus..

Recommendations

The following recommendations were made:
Schools for the blind should incorporate structured abacus lessons to improve numeracy skills
a. Workshops should be conducted to equip teachers with effective abacus teaching strategies.
b. The government and NGOs should provide abacus and braille toolsinstructional materials.
c. Individualized instruction should be prioritized to enhance students' engagement.

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