EFFECT OF COMPUTER SCREEN READER ON MATHEMATICS LEARNING OUTCOME OF STUDENTS WITH VISUAL IMPAIRMENT

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ABSTRACT
This study investigated the effect of computer screen reader on mathematics learning outcomes of students with visual impairment in Port Harcourt, Nigeria. The study employed the use of a pretest-posttest, control quasi-experimental 2x2x2 factorial design. Twelve participants, six students in each of the experimental and control groups were purposively selected for the study. Seven hypotheses were tested at a 0.05 level of significance. A researcher-made Mathematics Achievement Test (MAT) validated by three experts was used to collect data for the study. The MAT was trial tested and subjected to the Kudar Richardson-20 formula to give a reliability estimate of .78. The study was carried out for twelve weeks. The experimental group was subject to the use of screen reader while the control group was given a placebo of conventional teaching method in mathematics instruction. The data collected was analyzed using Analysis of Covariance (ANCOVA). The findings of the study revealed that: there is a positive significant effect of computer screen readers on mathematics learning outcomes of students with visual impairment. The experimental and the control groups have a post-test mean of 82.829 and 59.671 respectively after adjustment with an F-value =33.32; p= .000<.05 at df =1,9 and an Etta square value of .787. It was recommended among others that Mathematics teachers of learners with visual impairment should be trained on the use of computer screen reader for instructional delivery for students with visual impairment particularly for mathematics instruction.

Keywords: Mathematics, Computer Screen Reader, Mathematics Learning Outcome

INTRODUCTION

Mathematics as a subject affects every aspect of human life from childhood to adulthood. It is the bedrock of innovation and invention in the world of science and technology and plays a great role in the social-economic development of any nation. The problem-solving, critical thinking skills, and attention to detail, offered to students in mathematics lessons are vital resources that are significant to broader areas of life (Dada & Dada, 2014) when it comes to decision-making as these students strive to become productive members of society. Students' achievement in Mathematics over the years has not been encouraging at the primary, secondary, and tertiary levels of education in Nigeria. The situation is even more challenging for students with visual impairment who lack meaningful vision for concrete visual tasks (Bilal, 2020).The ability to accurately read and subsequently comprehend a mathematical expression is vital to the understanding of mathematics and mathematical concepts.

Mathematics learning ordinarily demands the ability to see. The ability to see is an invaluable asset of man, either in school or in the larger society. Inability to see therefore creates difficulty in social and school adjustment for the vulnerable. When sight is lost, students are exposed to certain levels of difficulties in the process of acquiring knowledge regardless of their mental ability (Dada & Fagbemi 2014). This fact poses a great challenge for students with visual impairment to acquire knowledge and compete effectively with their sighted counterparts in the school and society at large no matter how gifted or talented they may be (Dada, 2016; Dada & Fabgemi, 2014), especially in the field of mathematics which involves high visual demands in manipulating figures.

Mathematics learning for students with visual impairment in an appropriate learning environment should be from simple to complex, giving room for transfer of previous knowledge to new learning situations (Cavalluzzo, Lowther, Mokher, & Fan, 2012).). This progression from simple to complex is made much easier and provides a better learning pace with a computer screen reader for learners with vision disability (Bradford, 2015; Ramani, & Patadia, 2012). Appropriate learning pace enhances appropriate feedback during drill and practice and ensures good mastery when computer is deployed (Ramesh, 2016).

The Vygotsky Socio-cultural theory provide a framework for this study. The theory maintained that children are born with basic biological constraints on their minds. Each environment, however, provides "tools of intellectual adaptation."These tools allow children to use their abilities in a way that is adaptive to the environment in which they live (Santally, Boojawon, & Senteni, 2004).The socio-cultural perspective maintained that our psychological and cognitive growth is guided, in part, by people who are in mentor-type roles, such as teachers and parents (Ravindra, 2006). Other times, we develop our values and beliefs through our interactions within social groups or by participating in events to develop the zone of proximal.

An important concept in socio-cultural theory is known as the zone of proximal development. Vygotsky observed that this is "the distance between the actual development level (of the learner) as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers.”

This theory is relevant to the present study because the use of computers screen reader in our educational system provides a learning-environment that has come to stay. The computer screen reader provides a social support system for students and learners with visual impairment during independent drill and practice in mathematics lesson through its audio feedback. This ensures that students with visual impairment are properly guided during independent study. Teachers' methods of presenting the contents to students with visual impairment is greatly enhanced through the screen reader as the students develop interest for the Mathematics, if the teacher is able to present the content in a manner that is motivating.

Dada and Akpan (2019) asserted that poor visual imagination has a negative effect on visually every aspect of mathematics learning including numeracy, visual and practical estimation. The lack of the sense or use of vision poses great difficulty for students with visual impairments in their social cognitive personalities (Egaga, Dada & Fagbemi, 2015),especially numeracy skills which involves understanding mathematical information such as knowing how the number system works and understanding whole numbers, decimals, fractions, percentages, charts, tables, and graphs amongst others. Bilal (2017) in his research on intellectual development through the progressive building up of mental images submitted that students with a visual disability had challenges and difficulties in memorizing and dealing with figures. However, it has been observed that the acquisition of mathematical skills can be more difficult for students with visual impairments due to the abstract nature of many essential concepts and the highly visual presentation of the subject. In addition, the highly visual nature of mathematics, and the use of graphics to convey important information, present additional obstacles for students with visual impairment. The absence of a meaningful vision for concrete visual tasks in the teaching-learning process, especially in the field of mathematics which involves high visual demands in manipulating figures has made students with visual impairment perceived mathematics as a very difficult subject and a no-go area, despite its importance in their daily life.

There are specific objectives a teacher hopes to achieve in every mathematics lesson (Dada & Dada, 2014), but unfortunately, there is considerable evidence to indicate that these objectives are not being met, especially for students with visual impairment, who have become passive, instead of active participants in mathematics lessons due to the high level of visual procedures involved. Students with visual impairment are confronted with challenges during calculations involving measures of central tendency in mathematics during the teaching-learning process due to the total absence or partial visual memory as a result of vision loss(Dada, Swem, & Ausugh, 2017). Students with visual impairment depend more on their auditory and haptic perception rather than the visual process to benefit from classroom instructions or any teaching-learning process. This plays a great role in the various learning outcomes observed from students with visual impairment in calculations that involve the mean, median and mode of a given set of scores. These differences could be dependent on the intervention measure, age of onset and gender among others. This calls for a keen consideration of the mental and chronological age of students with visual impairment, their preference for mathematics lessons with regards to gender and an appropriate intervention measure that ensures inclusion for mathematics lessons according to the principle of equality in the teaching-learning process.

For students with visual impairment to develop an interest in mathematics and benefit from the teaching-learning process, the intervention measure must be captivating, arousing the interest of the student, and providing multiple pathways to learning. Computer Screen readers which is an example of assistive technology play a great intervention role during calculations in mathematics that involves measures of central tendency for students with visual impairment despite their loss of vision for the meaningful concrete visual task (Akah et. al., 2022; Shen, Lee, & Tsai, 2008). A computer screen reader is a generic term used for software that helps individuals with visual impairment use a computer. As the name implies, a screen reader reads content on the computer's screen and web browsers like text, images, and links, or content made visible by the computer operating system such as icons, menus, files, applications, figures, and folders.

The software will then translate that content or data into a format the user (students with visual impairment) is able to consume and interact with such as audible speech. The audio variety computer screen reader converts content into speech through a text-to-speech (TTS) engine which can be perceived through computer speakers or earphones. There are different computer screen readers that can serve the learning needs of students with visual impairment. The most popular programs are JAWS and NVDA for Windows computers. Nearly all computers have a screen reader function built in. The best choice for a computer user depends on the type of computer and the suitable browser for the computer involved.

JAWS (Job Access with Speech) which is the mainstay of this work, is a computer screen reader for Windows and works well with Internet Explorer, Chrome, or Firefox browsers. Jaws is one of the first screen reader and was launched for Windows 10 in 1995. The JAWS is extremely popular and widely used by students with visual impairment either in school or in the workplace. The JAWS screen reader in a computer announces whatever comes on the screen of the computer to students with visual impairment during the input and output process, making it easy for students with visual impairment to receive feedback from the computer, and issue the right command for the progress of the instructional process from one stage to another (Schnackenberg & Sullivan, 2000). Computer Screen readers as an example of Assistive technology is generally described as a designed program that promotes greater independence by enabling students with visual impairment to perform the task that they were formerly unable to accomplish or had great difficulty accomplishing, by providing enhancements to or changed method of interacting with the design needed to accomplish such tasks.

The perception of mathematics as a very difficult subject and most times a no-go area by students with visual impairment has greatly affected their interest and performance in the subject. This is because vision plays a great role in the process of acquiring knowledge, especially in the field of mathematics which demands meaningful vision in manipulating figures. Thompson, (2018) observed that the acquisition of mathematical skills can be more difficult for students with visual impairments due to the abstract nature of many essential concepts and the highly visual presentation of the subject. The high visual nature of mathematics and the use of graphics to convey important information present additional obstacles for students with visual impairment. The absence of meaningful vision for concrete visual tasks in the teaching-learning process, especially during calculations involving measures of central tendency in the field of mathematics which involves high visual demands in manipulating figures has adversely affected the interest and performance of students with visual impairment in the subject.

The interest and performance of students with visual impairment during calculations for mean, median, and mode for a given set of scores or distribution can be properly managed, and their learning outcome carefully observed when computers with screen readers are deployed in the intervention process, the age of onset of the impairment carefully considered, and their concerns across gender lines carefully noted. Bearing this in mind, the concern of this study was to investigate the effect computer screen readers have on the mathematics learning outcome of students with visual impairment in the Port-Harcourt Metropolis of Rivers State, Nigeria.

Hypotheses

1. There is no significant effect of computer screen reader on the mathematics learning outcome of students with visual impairment.
2. There is no significant interaction effect of computer screen reader, gender, and age at onset on mathematics learning outcome of students with visual

Research Method

This study deployed the use of a pretest-posttest, control quasi-experimental 2x2x2 factorial design. The factorial design means that there were two levels of instructional delivery (conventional teaching-learning for the control group and the use of a computer screen reader for the experimental group); two levels of gender variable (male and female participants) and two levels of age at onset (before and after age 7 years). The sample for this study comprised twelve (12) students with visual impairment. The study deployed a researcher-made Mathematics Achievement Test (MAT). This researcher-made test was the instrument used by the researcher for the pre-test and post-test to collect data for the study. The test instrument (MAT) contained twenty (20) multiple choice questions with options A to D. The instrument was subjected to scrutiny by experts from the field of mathematics and test and measurement. The MAT was trial tested students in St. Joseph School for the Blind in Obudu and the data collected was subject to Kuder-Richardson 20 formula for the reliability estimate. The reliability coefficient was .78. The difficulty index of the MAT was kept at .05 for all the 20 items

The intervention involved the use of conventional method for the control group, and computer screen reader for the experimental group. Six weeks of five lesson periods per week were used for the intervention. Students in the experimental group were taught to make basic calculations in measures of central tendency using a computer with the JAWS screen reader installed in it. This was followed by practice exercises carried out individually to enhance understanding and acquisition of practical skills for calculating the mean, median, and mode of a given distribution. Students in the control group were also taught how to calculate the mean, median and mode of a given distribution conventionally and given the opportunity to practice with many exercises to enhance understanding. All twelve participants took part in the post-test..Analysis of Covariance (ANCOVA) was used to test the hypotheses at a 0.05 level of significance.

Results

The results of the data analysis are presented according to the hypothesis

Hypothesis 1.

There is no significant effect of computer screen readers on mathematics learning outcomes for students with visual impairment. The students' pre-test and the post-test result were used for the analysis. The hypothesis was subjected to testing using analysis of covariance (ANCOVA) at a .05 level of significance. Table 1 present the

Table 1: Computer Screen Readers and Mathematics Learning Outcomes

		After treatment *(Unadjusted)*		After treatment *(Adjusted)*	
Treatment	N	Mean	Std. Deviation	Mean	Std. Error
Experimental group	6	82.50	5.244	82.829[a]	2.801
Control group	6	60.00	7.746	59.671[a]	2.801
Total	12	71.25	13.336		

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Partial Eta Squared	Observed Power[b]
Corrected Model	1543.421[a]	2	771.711	16.824	.001	.789	.994
Intercept	537.906	1	537.906	11.727	.008	.566	.861
Pre-test score	24.671	1	24.671	.538	.482	.056	.101
Treatment	1528.421	1	1528.421	33.321	.000	.787	.999
Error	412.829	9	45.870				
Total	62875.000	12					
	1956.250	11					

a. R Squared = .789 (Adjusted R Squared = -.742)

b. Computed using alpha = .05

From table 1, the mean scores of 82.50 and 60.00 were observed in experimental and control groups respectively before adjustments were made for the effect of the pre-test. The adjusted means (controlling for the covariate 'pre-test') for each study group (experimental and control group) were 82.829 and 59.671 respectively. This means that the effect of the 'pre-test' has been statistically removed. From these adjusted means, it is clear that the experimental group performed better in their post-test score even after adjusting for pre-test scores with the mean difference of 23.158[*] which was statistically significant (see table 4). The calculated $F_{(1, 9)}$ was 33.321, with a p-value of 0.00; ($P<.05$). The result of the analysis indicates that there was a significant mean difference between control and experimental groups in their post-test scores on the mathematics achievement test whilst adjusting for the pre-test. The partial Eta Squared (η^2) was compared with Cohen's guidelines (0.2 – small effect, 0.5 – moderate effect, 0.8 – large effect) indicating the values of the effect size. The calculated η^2 on the treatment groups (experimental and control groups) was .787 which indicates a moderate but significant effect size. Furthermore, η^2 of .787 revealed that 78.7% of the variance in the post-test scores is explained by the use of computer screen reader intervention within the study group. The result of the analysis was significant at .05 because the calculated p-value of .00 was less than the acceptable p-value of .05, hence the null hypothesis which stated that was rejected while the alternate hypothesis was retained. This result implies that the use of computer screen readers has a significant effect on the mathematics performance of students with visual impairment in the study group.

Table 2: Bonferroni Pairwise Comparisons of control and experimental group

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	p-value
Experimental group	Control group	23.158*	4.012	.000
Control group	Experimental group	-23.158*	4.012	.000

*. The mean difference is significant at the .05 level.

There is no significant interaction effect of computer screen reader, gender and age at on-set on mathematics learning outcome of students with visual impairment. In this hypothesis, the interaction effect of the entire variables (gender, age at the onset of visual impairment, mathematics learning outcome) was taken into consideration. Data collected from 12 respondents in both the control and the experimental groups were used for the analysis. the null hypothesis was analyzed using Analysis of Covariance (ANCOVA) at .05 level of significance. the result of the analysis is presented in table 2.

Table 2: Interaction effect of age at the onset of visual impairment, gender, computer screen reader and learning outcome of student with visual impairment in mathematic.

Source	Type III Sum of Squares	Df	Mean Square	F	p-value	Partial Eta Squared	Observed Power[b]
Corrected Model	1907.639[a]	8	238.455	14.716	.025	.975	.840
Intercept	624.509	1	624.509	38.541	.008	.928	.975
Pre-test score	1.389	1	1.389	.086	.789	.028	.055
Age at onset	256.517	1	256.517	15.831	.028	.841	.751
Gender	66.774	1	66.774	4.121	.135	.579	.296
Treatment	1329.371	1	1329.371	82.041	.003	.965	1.000
Age at onset * Gender	.261	1	.261	.016	.907	.005	.051
Age at onset * treatment	15.609	1	15.609	.963	.399	.243	.109
Gender * treatment	17.444	1	17.444	1.077	.376	.264	.116
Age at onset * Gender * treatment	.013	1	.013	.001	.979	.000	.050
Error	48.611	3	16.204				
Total	62875.000	12					
Corrected Total	1956.250	11					

a. R Squared = .975 (Adjusted R Squared = .909)

b. Computed using alpha = .05

Table 2 presents the interaction effect of age at the onset of visual impairment, gender, computer screen readers and mathematics learning outcome of students with visual impairment when measured using achievement tests. The result of the analysis revealed that the calculated F-value was .001at 1 and 3 degrees of freedom with a p-value of .979 and a partial eta square of .050. The result of the analysis was not significant because the p-value of .979 was greater than the acceptable p-value of .05; (P > .05). Additionally, partial eta squared η^2 calculated of .050 indicates that the effect size is small. This implied that only 5% of the variance in the post-test is explained by the interaction effect of age at the onset of visual impairment, gender and computer screen reader when adjustment is made for the effect of the pre-test. With this result, the null hypothesis which stated that there is no significant interaction effect of a computer screen reader, gender and age at onset on mathematics learning outcome of students with visual impairment was accepted while the alternate hypothesis was rejected. This implies that the interaction effect of computer screen reading, gender and age at the onset of visual impairment does not have a significant effect on the mathematics learning outcomes of students with visual impairment within the study population.

Discussion

The first hypothesis was meant to test the effect of computer screen readers on mathematics learning outcomes of students with visual impairment. The post-test result on the achievement test as reflected in the statistical analysis even after adjustments have been made for the effect of the pre-test indicates that there is a positive significant effect of computer screen readers on the mathematics learning outcome of students with visual impairment in the study area. The effectiveness of the electronic device in enhancing teaching and learning has been well documented, however, the finding pays specific attention to computer screen readers. The non-prevalence of this software has been a barrier to teachers (Bayturan, 2012; Bayode 2017).

Many empirical studies Owonta (2012); Owolabi (2012), Omiyale (2014) discover the importance of assistive technologies to the learning outcome of students with visual impairment. Nonetheless, they emphasize its inadequacy and absence in most schools and their immediate environment. The findings of this study thus agree with Owolabi (2012) that the use of assistive technology enhances the educational attainment of students with visual impairment to a great extent. The study revealed that onscreen reading negatively affected academic learning outcomes and that male students were more negatively affected than female students. It was further discovered that children taught with Assistive Technology performed better than those taught without assistive technology.

Interaction effect of age at the onset of visual impairment, gender, computer screen readers and mathematics learning outcome of students with visual impairment was assessed using Analysis of Covariance (ANCOVA). The calculated F-value of .001at 1 and 3 degrees of freedom with a p-value of .979 and a partial eta square of .050 indicate that the result of the analysis was not significant at .05 with a very small effect size of 5%. This result led to the acceptance of the null hypothesis that there is no significant interaction effect of a computer screen reader, gender and age at onset on mathematics learning outcome of students with visual impairment was accepted while the alternate hypothesis was rejected. Experimental outcomes favoured the use of computer screen readers on mathematics learning outcomes of students with visual impairment (Sharma, 2016). However, the interaction effect of a computer screen reader, gender and age at the onset of visual impairment was not significant.

Conclusion

Based on the major findings of the study it was concluded that; there is a positive significant effect of computer screen readers' use on mathematics learning outcome of students with visual impairment as reflected in the post-test result. Meanwhile, gender and age at on set have no significant effect on learning outcomes in mathematics after statistically adjusting for the effect of pre-test. This implies that the use of screen reader is not affected by the age and age at onset

Recommendations

In view of the positive effect of computer screen reader on the mathematics learning outcome of students with visual impairment, it is recommended that government should provide screen reader facilities and train teachers and students on the utilization of screen reader

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