CAN OPTICAL LOW VISION DEVICES IMPROVE READING OUTCOMES AMONG LEARNERS WITH LOW VISION? A CASE OF THIKA PRIMARY SCHOOL F

OR THE VISUALLY IMPAIRED, KENYA.

RESEARCH REPORT

SEPTEMBER 2019

FOREWORD

Learners with visual impairment experience difficulties in education. In most cases, the blind get support from their families, schools and other stakeholders in Education because it is relatively easy to notice an individual who is blind. On the other hand, learners with low vision have little support and accommodation because few people are likely to notice low vision among children.

Further, disability researches across the world classify bind and low vision under one category of visual impairment. With the attention given to the blind by majority of decision makers, visual impairment is mistakenly used to mean blindness, as a result, individuals with low vision remain unnoticed among the population of the visually impaired. Consequently, this group of people, especially children in school lack reasonable accommodation that would otherwise enhance their academic achievement and general quality of life.

The findings in this study presents evidence in support of using optical low vision devices to improve reading outcome and reading accuracy for learners with low vision. The results demonstrate the positive impact that can be made to learners with low vision if early identification and comprehensive assessment can be given to these learners in school. I urge parents, teachers, policy makers and all other education stakeholders to pay attention to the findings of this study that may go a long way in improving the quality of learning outcome for our children and learners with low vision.

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EXECUTIVE SUMMARY

This study sought to establish the influence of optical low vision devices on reading outcome for learners with low vision. The study adopted a quasi-experimental design in which 12 learners with low vision who use print as their main medium for reading and writing from Thika school for the visually impaired were studied for a period of 9 weeks. A comprehensive low vision assessment to establish appropriate magnification required by learners in the intervention group was conducted before issuing the optical low vision devices. Data on learners' reading speed was collected by recording the number of words read correctly per minute and the number of errors made during reading. Data on learners' perceived usefulness and ease of use of optical low vision devices was collected from the intervention group through interviews. Quantitative data was processed using Stata 15 while qualitative data was analysed thematically. The findings of the study revealed that provision of appropriate optical low vision devices (OLVD) and training learners on their effective use, improves reading outcome. This was evidenced by a significant increase of the mean reading speed of intervention group compared to control group. It was also found that the average number of reading mistakes made by intervention group was lower than the control group. The study recommends that children with low vision should be provided with optical low vision devices and trained on their effective use to improve reading outcome hence promote access to quality education.

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ABBREVIATIONS AND ACRONYMS

DVA	Distance Vision Acuity
F+F	Fix and Follow Vision
FPL	Forced Preferential Looking
HCL	Hard Contact Lens
ICD	International Classification of Diseases
KISE	Kenya Institute of Special Education
KNEC	Kenya National Examinations Council
KSB	Kenya Society for the Blind
KU	Kenyatta University
LVA	Low Vision Aids
MOE	Ministry of Education
NRC	Normal Retinal Correspondence
NVA	Near Vision Acuity
ON	Optic Nerve
WHO	World Health Organization

CHAPTER 1: INTRODUCTION AND BACKGROUND OF THE STUDY

1.0 Introduction

Introduction section gives a brief summary of the project, states the problem, highlights the purpose of the study, gives the objectives of the research, defines terms used in the study and gives the concept of the study.

1.1 Background of the study

Within the human sensory system, vision stands out to be a very important sense. It provides a huge fraction of total information a person gets through the senses. This account for more than three fourths of total sensory input to the brain. It is estimated that 85 percent of the information an individual receives each day, which accounts for more than three-fourths of learning is by use of vision (Pandey, 2018). While an individual with visual impairment can perform most activities in life that do not require sight, persons with visual impairment experience a significant limitation in interacting with their physical surrounding. The definition of a person with visual impairment makes reference to the degree of visual acuity, the field of vision and their general visual efficiency.

According to International Classification of Diseases (ICD) (2018), a person whose visual acuity in the better eye with best optical correction has a presumed acuity measures of <6/18 (0.3) to >3/60 (0.05) and a corresponding visual field of less than 20 degrees, the person is said to have low vision (WHO, 2018).

Gibson, Pousson, & Laux, (2018) in their research on how people understand disability identity development in persons with visual impairment and particularly low vision, found out that there was still a problem of understanding and supporting persons with low vision in United States, and indeed across the globe. The researchers observed in the same study that there was still so much to be learned in terms of supporting as well as identifying people with visual impairments and those with low vision included.

Le Fanu, Bassendine, McCall, and Myers (2018) in their guide report on participatory training and studies for children with visual impairments in Senegal, acknowledged that school going age children with visual impairments require assistive technologies to help them cope with learning. Those with low vision need spectacle glasses, reading stands and other OLVDs as may be prescribed by low vision therapist. The report records that, this kind of assistive technologies and

OLVDs may not be readily available for children who need them, and if available they may be in poor working condition. The report further recognizes that even with their availability, children may not receive the specialist training which will enable them to use these equipment effectively. A study by Mwalongo, (2018) on assessment and inclusiveness of visually impaired students in Tanzania found that some of the major issues for learners with visual impairments is substandard level of teaching and inadequacy of appropriate teaching apparatus.

Additionally, report on the National Survey on Children with Disability and Special Needs in Kenya (KISE, 2018) found the prevalence of visual impairment in children at 3 percent. This translates to 671,205 visually impaired children. These figures included low vision as well as children who are blind. According to Kirk, Gallagher, and Anastasiow (2006), about 80 percent of persons with visual impairment have low vision and only a small number of persons with visual impairments are blind. Hence, low vision represents the largest sub-group of persons with visual impairment. Going by this, it can be deduced that there are 536,964 learners in Kenya with low vision.

Visual impairment hinders one from carrying out daily routine, it also has a negative impact financially, academically and socially. Low vision in children persists for a lifetime unlike when it is experienced in adulthood. A major difficulty reported by learners with low vision is the hindrance to do normal expected tasks especially reading. Reading is a fundamental requirement for one to pass exams; the determinant of academic excellence (Stelmack et al., 2008). A major challenge in reading by learners with low vision is the font size. Wolffsohn and Eperjesi (2010), opined that there is need for enlarging letters and numbers for the sake of learners with low vision. Assistive technology in general and optical low vision devices, in particular, are widely used means of providing magnification to mitigate negative reading outcomes caused by low vision. According to Jutai, Strong, and Russell (2009), the use of optical low vision devices improves reading ability and lead to academic achievement, thereby contributing to increased learners' chances of learning and acquiring different experiences that contribute to learner's adjustment and educational achievement.

1.2 Statement of the Problem

The ability to read print is an essential skill in the 21st century because most information is presented in text; websites, books, magazines, newspapers and many other forms of writing. Low vision affects the child's ability to read, causing great impediment to their educational success,

employment prospects, independence and quality of life. Improving visual performance can help enhance vision functioning. Assistive techniques such as OLVDs enhance visual performance. Several studies reveal that close to half of the children with low vision have in the past shown an ameliorated performance in terms of short sightedness with the aid of spectacles, and/or with a magnifier (Silver, et al., 2005; Ager, 1994; Ager,1996). Even though studies and literature concerning use of devices for the low vision indicate positive outcomes, there is limited empirical evidence in the Kenyan context. Hence this study sought to finding out whether optical low vision devices can improve reading outcomes among learners with low vision in Kenya.

1.3 Purpose of the Study

The purpose of the study was to find out the influence of optical low vision devices on reading outcomes among learners with low vision.

1.4 Research Objectives

The objectives of the study were;

1. To establish the influence of optical low vision devices on reading speed among learners with low vision,
2. To find out the perception of learners with low vision on the use of optical low vision devices for reading.

1.5 Significance of the Study

The study findings are anticipated to provide salient information that will influence the acceptance and use of optical low vision devices by learners with low vision. Additionally, the study will be beneficial in building a knowledge base of perceptions of learners with low vision on the use of optical low vision devices for reading. Finally, the study will help researchers, policy makers, teachers and other stakeholders to make references on this work with the aim of building more knowledge in the field of education for learners with low vision.

1.6 Scope of the Study

This study focused on the influence of optical low vision devices on reading outcomes among learners with low vision. Reading outcome in this study comprise of reading speed and perception of learner with low vision on the use of optical low vision devices. This study was limited to one aspect of reading performance; reading speed. Therefore, other aspects of reading performance

including comprehension and fluency are beyond the scope of this study. In addition, the time taken to conduct the study was limited to two months as compared to previous related studies conducted.

1.7 Operational Definition of Terms

Critical print size: The minimal print that one can read with fastest speed

Reading Speed: The number of words a person reads correctly per minute

Reading performance: Refers to reading accuracy, speed, automaticity, prosody and comprehension.

Reading Acuity: the smallest print a person can read and not make significant errors.

Reading errors: Is the difference between the true and actual word as read by a learner

Low vision: is when the better eye has a visual acuity whose best possible correction is <6/18 (0.3) and >3/60 (0.05) and/or a visual field of less than 20° in the best eye

Perception: Is the satisfaction and experience of learners with use of the OLVD

Visual acuity: is the measurement how well a person can see straight ahead.

Visual field: is the whole area one can see with eyes focused on a central field of an object.

Visual efficiency: is the ability of the eye to mediate performance of the vision in carrying out daily routine.

Chapter 2 **LITERATURE REVIEW**

2.0 Introduction

This chapter presents the related literature of the study. Literature was reviewed under the following subsections: Overview of low vison, reading with low vison and perceptions of learners with low vision on use of optical low vision devices.

2.1 Overview of Low vision

Low vision can be categorized as a visual disorder, which is irremediable through spectacles with corrective refractivity, medical or surgical treatment, and contact lenses. Low vision hinders one from efficiently undertaking activities such as reading, and in the long run negatively impact academic performance, as well as quality of life. There is no universally acceptable definition of low vision since most of the definitions are pegged on the clinical measure without considering the functional aspects. As a consequence, the definition of low vision differs from one country to the other, and different researchers have varied definitions too. Although there is no constant definition of low vision that applies to every situation. Nevertheless, there is an agreement by low vision experts that low vision entails continuity of visual defects from healthy vision and blindness (Stelmack et al., 2001; Geruschat & Smith 2007). Attempts are being made to come up with a universally acceptable definition of low vision to help set up standards that can help measure the suitable criteria, explanation of data from epidemiological studies and access of related services (Vashits et al., 2017; WHO, 2002; Lueck 2004).

As per the 11th revision of WHO-ICD (2018), low vision is a condition when one has a visual acuity of <6/18 (0.3) and >3/60 (0.05) and/or visual field 20° less with best available correction (WHO, 2018). Surveys on populations around the globe, on estimates of low vision have applied this definition (Van Timmeren et al.; Li et al., 2018; Ganesh et al., 2018.)

In Kenya, there is no specific definition of low vision for legal provisions such as registration for social benefits. Therefore, people with low vision as registered as legally blind to access social benefits provided for by the Constitution of Kenya 2010. For this study, the WHO definition of low vision will be adopted for use and interpretation.

For the purpose of educational provision for learners with low vision in Kenya learners are categorized into five groups; category 1 are includes learners who are totally blind who fully rely on braille as the main medium of reading and writing, category 2 refers to those with some vision

but not good enough to read print hence use braille, category 3 are learners who can use print with the aid of magnification. Category 4 comprise learners who can read print without magnification and other special technique while category 5 are learners whose vision is normal and do not require special education services. These categories have been in existence since 1995 and have been found to be of great help when explaining educational needs of learners with low vision (Verweyen & Hyvärinen, 2000).

2.1.1 Prevalence of Low Vision

WHO (2010) estimates that there are approximately 285 million individuals who have visual impairment across the globe? Out of these, around 39 million accounts for the blind and the rest accounts for those with low vision. This indicates that a large number of people with visual impairments have low vision in comparison to those who are blind (Pascolini., 2010). The World Health Organisation task force on data on blindness reported that 90 per cent of all persons who have low vision are found in under developed countries with 75 per cent of them in Asia and Africa (Pascolini, 2010).

2.1.2 Prevalence of Low Vision among Children

About 140 million children have low vision and close to 50 million children with blindness globally (WHO,2010); Buorne et al. 2017). Since most of the data for children with low vision are obtained from schools for visually impaired children, it is difficult to estimate the precise percentage of low vision children (WHO 2010; Glewwe, Park & Zhao, 2016). In most cases, most of the researches either report incidences of visual impairment as a result of refractive errors or blindness (Varma et al. 2016; Naidoo et al. 2016), few studies however, directly report prevalence of low vision correctly (Dandona et al. 2002; Naidoo et al. 2003; Murthy et al. 2002; Goh et al., 2005; He et al. 2004;).

According to the Kenyan Ministry of Health Strategic Plan 2017, there are 224,000 children who are blind while another 750,000 have low vision. A report on a National Survey of Children with Disability and Special Needs in Kenya (KISE, 2018) established that the prevalence of visual impairment in children is at 3 percent. This translates to 671,205 children with visual impairments. Going by this it can be deduced that there are 536,964 children with low vision in Kenya.

2.1.3 Effect of Low Vision in Visual Functions

There is a wide range of visual function loss in children with low vision, depending on the cause, prognosis and the onset. Reduced visual functions have been proved to be the significant hindrance

to studying performance of children with low vision (Husseindeen et al., 2018). However, according to Eisner et al., (2007), apart from reduced visual acuity, there are other deficits on visual functions, which can impede reading such as reduced contrast sensitivity, impaired color discrimination, impaired dark and light adaptation and impaired ocular motility.

2.2 Reading and Low Vision

Reading is of fundamental importance in anyone's way of living. In children, reading is a gateway to knowledge, brilliant performance academically, and getting a good job in the future. Consequently, fluency in reading is a very important factor in a child's education. It is enhanced by a collectivity of symbols on a page or computer monitor. The crucial factors of determining legibility of the print, is the symbols' shape and size.

Significant researches indicate that children with low vision, develop their reading techniques at a slower pace compared to normal sighted peers. (Hoffman, 2017; Bracher & Mata, 2017; Gompel et al., 2012). This happens even if the child has the same level educationally and cognitively; learners who have low vision principally do not attain the same reading speed as their counterparts with normal vision (Glewwe et al., 2016). Several explanations have come up to explain the phenomenon of reduced reading speed in leaners with low vision. The explanations connects the fact to problems that learners with low vision encounter when getting visual information from whichever sources such as printed text. One of the major explanations is the relationship between print type, font size and learners' ability to interpret.

In most cases, a reduced visual acuity interferes with the recognition of letters, hence the reading speed. Calabrese et al. (2016) found reading disabilities (i.e., reading less than 90 words per minute) to be higher among persons with visual acuity worse than 6/12. To ameliorate this Prescription of OLVDs is the most frequent means used to achieve acceptable reading speed (Corn, 1996). Although suitably magnified print provides a remedy for problems with seeing text, it additionally results in less letters or phrases that can be fixed at first quick sight. As a result, it requires one to take more glances in order read a sentence, of which it is time consuming, and requires one to adapt to use with required optical device. Dickinson (2002) averred that training persons with low vision on special reading techniques using OLVDs improve reading performance. From a Kenyan context, therefore, this study yields information that can be used by teachers and other stakeholders in the processes of deciding on the provision of OLVDs and training children who have low vision on the use in reading

2.3 Perception of Learners with Low Vision on Use of Optical Low Vision Devices

Perception from a psychological perspective has many definitions. However Ward, Grinstein and Keim, (2015) defines perception as "the process of recognizing (being aware of), organizing (gathering and storing), and interpreting (binding to knowledge) sensory information" or more simply "is the process by which we interpret or think about the things or the world around us, forming a mental representation of the environment".

Technology Acceptance Model as developed (TAM) by Davis (1989) is one of the most popular research models to predict use and acceptance of technology by individual users. The model has two key factors namely; perceived usefulness and perceived ease of use that influence use of technology. These two factors are influenced by external variables. In this study the external variables included assessment of visual functioning of each child, making necessary adjustment and also training on use of OLVD. The attitude to use is concerned with the user's evaluation of the desirability of device.

The user-acceptance on use of OLVD by learners can be equated to adoption of new technologies. In this regard, literature exists on technology acceptance in the field of information systems with well-established measures of user's attitude such as the classic Technology Acceptance Model (TAM) by Davis (1989) and other models developed from TAM such as the Unified Theory of Acceptance and Use of Technology (UTAUT) introduced by Venkatesh, Thong, Xu (2003), as well as other more recent models such as the UTAUT2 extension by Segura and Thiess (2015).

More specifically, the Technology Acceptance Model has been used in several studies to explore the perception of users towards use and acceptance of new technologies.

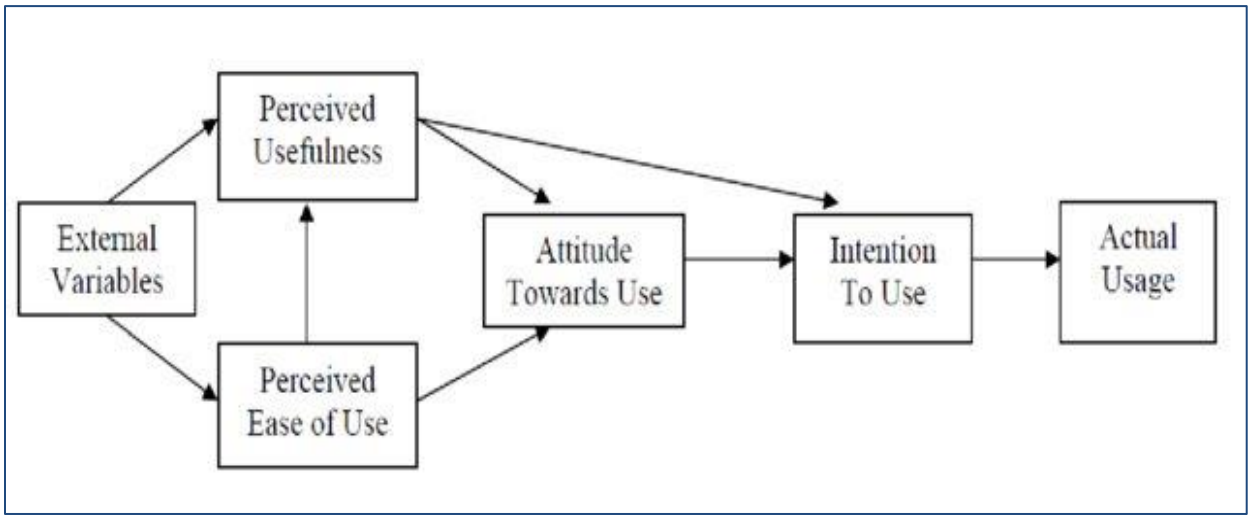

Figure 2.1: Modified version of Technology Acceptance Model (TAM)

Source (Davis, Bogozzi and Warshaw, 1989).

There are limited studies that have been conducted on perceptions of learners towards use of OLVDs. More commonly, the available studies are not on leaners but on acceptance of smart technologies. A study by Glewwe Park and Zhao, (2016) revealed that whereas social acceptability is critical, utility and usability are significant determinants for long-term adoption. The importance of utility and usability in the context of acceptance of OLVDs then comes into focus. Learners will form perceptions before or after use of OLVDs based on the utility and usability of the optical device. This can be related to the study for if the learners perceive the OLVDs as useful and easy to use, it will also influence their use and continued use of the devices.

Chapter 3 **RESEARCH METHODOLOGY**

3.0 Introduction

This section describes the study design with the analysis approach that was adopted. The chapter also explains the population of interest, sample size and approaches, instruments, data collection and analysis procedures that were used. Finally, ethical considerations of the study are discussed.

3.1 Research Design

The study adopted a quasi-experimental design, using double pre-test design approach. According to Fife-Schaw (2006), a quasi-experimental design is an empirical study that does lack the component of randomization. It was preferred in the design because there was no randomization in sample selection. Double-pre-test approach is an empirical approach in which pre-test is conducted twice to verify the normality of control and experimental group before intervention is applied.

3.4 Target Population

The target population in the study were learners with low vison in class four, five, six and seven from Thika School for the Visually Impaired. This comprised of 19 learners with low vision who uses print as their main medium of reading and writing. Learners from grade 1-3 were left out as it was assumed, they had not mastered the skills for reading. In addition, learners in class eight were not included because they were considered busy being candidates for 2019 National Examinations.

3.5 Selection Criteria

The participants for this study were learners with low vision in public primary schools in Kiambu County. Two groups of learners with low vision who use print as main media of reading and writing were selected from class four, five, six and seven. Six as experiment group and six in the control group. The inclusion criteria will be based firstly; on low vision learners classified as category three according to Kenyan categorization of persons with low vision. Secondly, learners whose reading impediment is due to reduced vision but not because of learning difficulty. Thirdly the reading performance is commensurate in both the experiment and control group.

3.6 Sample Population

The study purposively selected twelve (12) learners with low vision who uses print as their main medium reading and writing. The main reason of using purposive sampling is to allow selection of particular characteristics of the target population. In this study, the selection criteria formed a basis of purposive inclusion and exclusion of some learners in the study.

3.7 Description of the Intervention

The purpose of intervention for the sample population is to establish the impact of OLVDs on reading performance. This was achieved through providing OLVDs and special training on appropriate use. The optical low vision devices that were used included any device that enhances magnification for learners with low vision. Optical low vision devices examples are magnifiers which may be hand-held or mounted on a stand or on spectacles. The intervention involved having two-hour training and reading practising session every school day for seven days. The intervention group received training techniques on use of the OLVDs and reading practice while the control group will receive reading practice without the optical device.

3.8 Data Collection Procedures

The data collection process was done in three phases; the first phase was pre-test during which learners were given reading tasks and their present reading speed established. In the second phase (second pre-test), another reading test was given to the same learners and results of the two phases compared. Based on the results from the two phases, we would determine and partition the sample into two; intervention group and control group.

The time-lag between the first reading outcome that may be attributed to extraneous variables and control scheme empirically determined. and second pre-test should be reasonable in the context of a specific study (Jensen, et al., 2008). This double pre-test in quasi-experiments helps identify the likely variation. Appropriate OLVDs will be given to the intervention group, after assessment by a low vision therapist, as an intervention measure. These learners were trained on the efficient use of OLVDs to enhance their reading speed. Post-test reading tests will be given to both intervention and control groups to determine their reading outcomes in terms of reading speed. The results from the two groups was analysed to test the causal hypothesis on the use of OLVDs as an intervention.

3.9 Data Analysis

If there is no randomization in quasi-experimental research, it was wise to use more advanced statistical procedures (Reichardt, 2009). Descriptive and inferential statistical analysis approaches were used to study the causal hypothesis of the low vision OLVDs intervention. Independent sample t-test was used for analysis of both pre-test and post-test scores for a group of learners with low vision taking standard reading tests. This test was preferred because tests are related in belong to the same learners. Multiple regression analysis was used to minimize the initial differences between intervention and control group, which is important due to lack of randomization in quasi-experiment, by making compensating adjustments to the data. Stata15 software will be used to summarize the quantitative data and content analysis was used to detail the historical and demographic nature of research participants. To control for extraneous variables, a linear mixed effect model, where the coefficient of the time-group interaction term is the reading test before and after the intervention was taken into account as covariates. Tables and figures are used to provide a summary of findings.

3.10 Ethical Concerns

Ethical issues such as reliability, integrity, and validity were taken into account during the study. Ethical principles in this study included primarily centred on protecting learners with low vision who will be participating in the study. The core ethical principles of respect for persons, beneficence and justice were observed before, during and after the study. The researcher upheld high scientific standards in the inquiry process and guard against falsifying of data in pursuit of knowledge and truth about the impact of OLVDs on reading outcomes for learners with low vision

Chapter 4 **PRESENTATION OF FINDINGS, INTERPRETATIONS AND DISCUSSIONS**

4.1 Introduction

The purpose of this study is to determine the influence of optical low vision devices on reading outcomes among learners with low vision. This chapter presents the findings of the study and their interpretations in the Kenyan context. It begins by describing the general and demographic information of study participants before proceeding to the influence of optical low vision devices on reading speed among low vision learners and finally the learners' perception on the use of optical low vision devices in improving reading outcomes.

4.2 Description of Participants

Participants were 12 learners with low vision from Thika school for the visually impaired where 6 (50%) were female and 6(50%) were male as presented in the Figure *4.1*. The mean age of all participants was 13.75 years with a standard deviation of 0.57. The mean age of learners in the control group was 13.5 years with standard deviation of 0.72 and the mean age for the intervention group was 14 years with standard deviation of 0.93. The distribution of learners per class shows 25% from class 4, 17% from class 5, 25% from class 6 and 33% from class 7 as shown in Figure *4.1*.

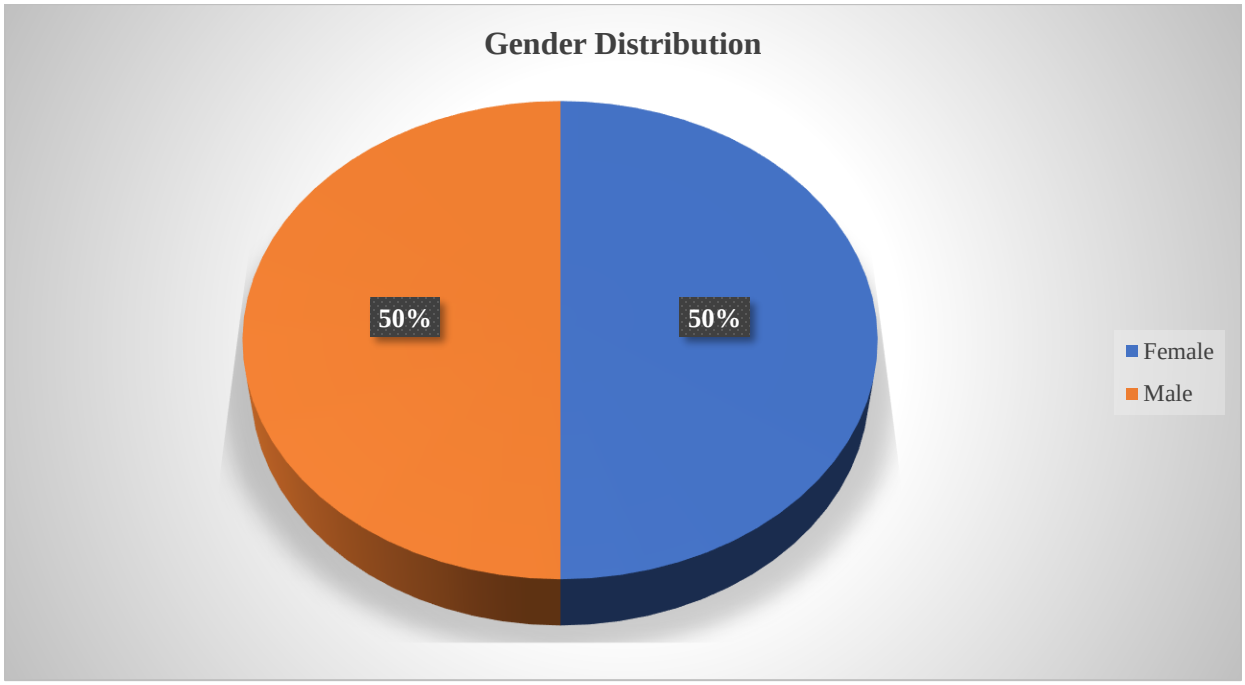

Figure 4.1: Distribution of gender in the study Population

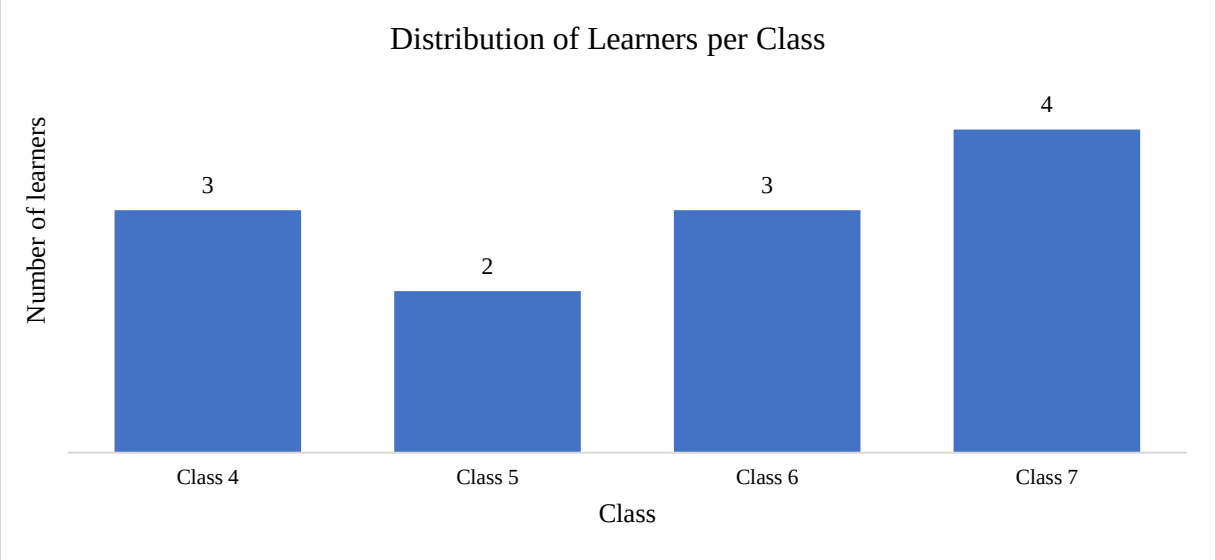

Figure 4.2: A bar chart for the distribution of learners per class.

4.3 Reading Tasks

Eleven different reading tasks for each class were used for data collection. They were prepared in English language in Arial font type, size 12 and line spacing of 1.5. Study participants were assigned standard reading tasks with respect to their class. The number of words in the reading tasks assigned to class 4 learners ranged between 134 and 155 (mean=142, SD=7.5) while for class 5 had between 151 and 245 words (mean=171, SD=25.7). Reading tasks for class 6 had between 201 and 216 words (mean=206, SD=4.3) while for class 7 had between 151 and 250 words (mean=223, SD=32.9).

The number of words in the reading tasks assigned to learners was guided by the oral reading fluency (ORF) technical report (Hasbrouck &Tindal, 2017) published by behavioural research and teaching (BRF). The ORF norms documents the standard number of words read per minute by learners without reading difficulties as follows; between 45 and 180 words per minute for grade 4, between 61 and 194 words per minute for grade 5, between 68 and 204 words per minute for grade 6 and between 79 and 218 words per minute for grade 7.

4.3 Influence of Optical Low Vision Devices on Reading Speed Among Learners with Low Vision

Reading speed in this study is a function of the number of words correctly read in a given time interval. The speed was determined by the number of words a learner was able to read correctly per minute. At the beginning of the study learners were given reading tasks and their reading speed

determined (pre-intervention). This formed the baseline upon which the progress of reading speed was measured. The partitioning of the sample into control and intervention groups was purposively done to obtain equal mean reading speed for each group. All the 12 study participants were trained in reading tips and provided with reading materials for practice. Additionally, the intervention group were trained on the effective use of their individually prescribed optical low vision devices. As presented on the Figure *4.3*, the mean reading speed for both control and intervention groups at the beginning of the study were 83 words per minute and at the end of the study, the mean speed for the control group was 103 words per minute and 119 words per minute for the intervention group.

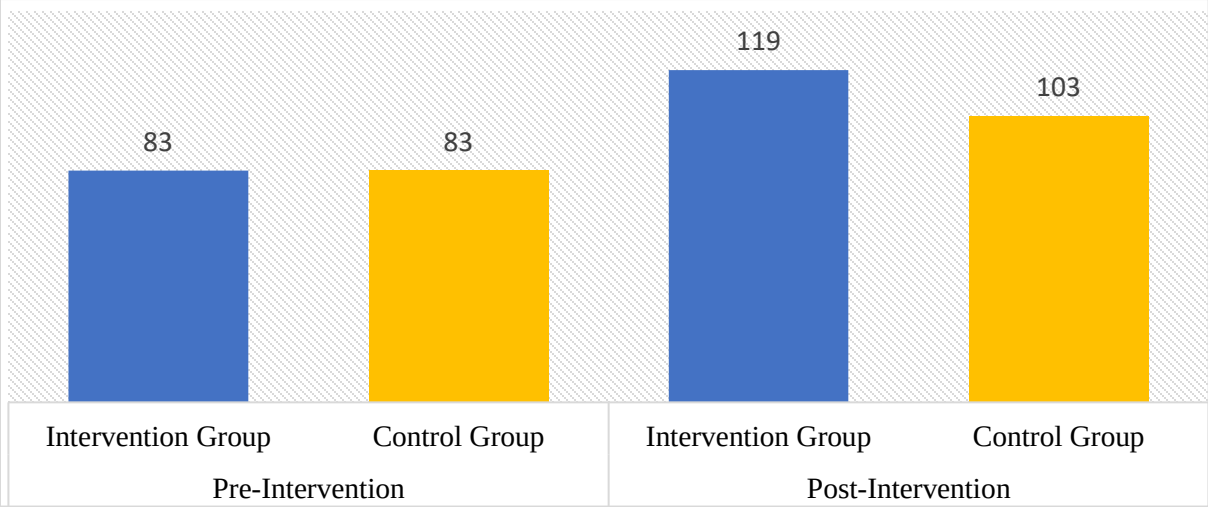

Figure 4.3: A column chart of the mean reading speed for control and intervention groups

Data was collected 11 times, 2 at the beginning of the study where all learners read their tasks without OLVD (pre-test 1 & pre-test 2) and 9 times where learners in the intervention group were using OLVD for reading. Data collection period took place at an equal interval of 2 days. Every data collection involved recording the number of words read by the learner and the number of errors committed. Data collection at multiple intervals was informed by the study findings by Savaiano and Hatton (2013) who observed that there is a functional relationship between repeated reading and reading speed for learners with low vision.

Figure *4.4* presents the reading speed for both groups (intervention and control) were at per before issuing of OLVD to the intervention group. The reading speed increased steadily for both groups, with a significant positive departure for the intervention group. It was found that the mean reading

speed for learners in the intervention group was higher compared to the control group at every measurement period.

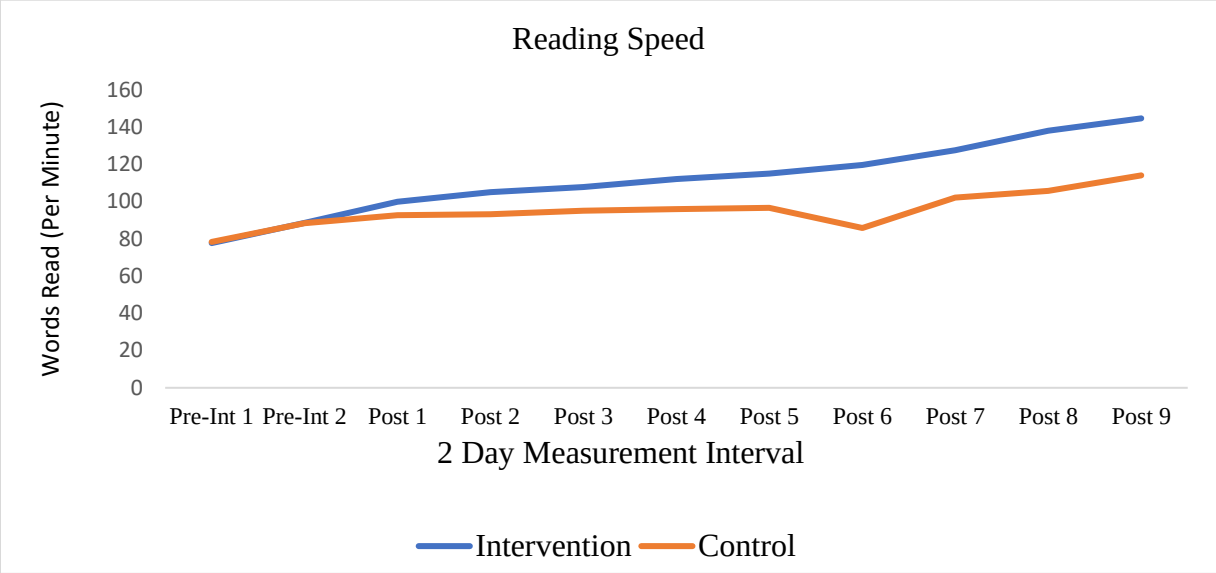

Figure 4.4: A time series plot on reading speed.

Additionally, it was found that the mean number of errors committed during reading reduced over time. The errors included omissions, substitutions and misreading of words. The summary statistics (mean and standard deviation) for reading errors committed in the pre-and-post-intervention stages is presented in Table *4.1*. The number of reading errors committed by learners in control group reduced by 40% while that of learners in the intervention group reduced by 45%, implying a 5% improvement in reading accuracy.

Table 4.1: Summary of Errors

	Group	**Mean**	**SD Dev**
Pre-Intervention	Intervention	11	5.34
	Control	10	5.60
Post-Intervention	Intervention	6	5.94
	Control	6	6.25
Error Reduction	Intervention	45%	
	Control	40%	

Figure *4.5* tracks reading errors for each of the study groups. The intervention groups indicate a consistent reduction in the number of reading errors as opposed to the control group whose variation remain visible even towards the end of the study.

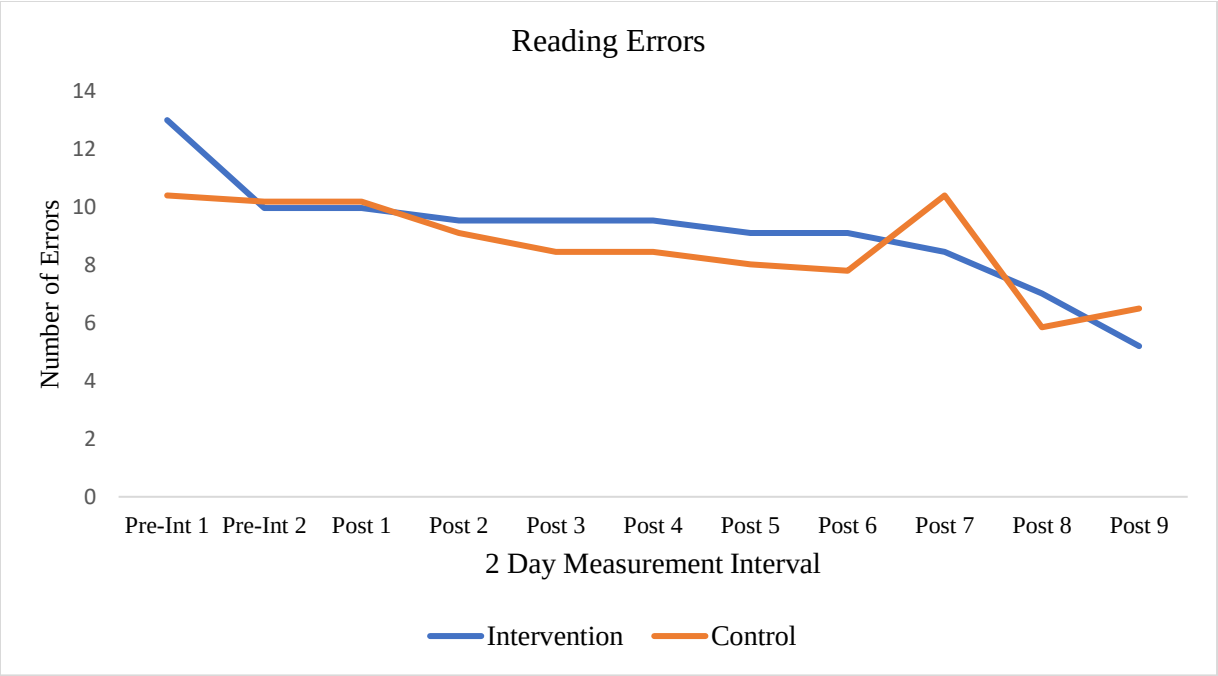

Figure 4.5: Line Graph for Reading Errors

The hypothesis tests using independent t-test statistics presented in Table *4.2* reveals significant differences between the mean reading speed for participants in the intervention group and those in the control group. The hypothesis that there is no difference between the mean reading speed for the intervention and control groups is rejected ($p=0.01<0.05$, $p=0.02<0.05$) at 95% confidence level. Thus, the reading speed of 119 words per minute attained by the intervention group is statistically different from the 103 words per minute attained by the control group. Since the two groups were constituted by learners with low vision, where intervention group used OLVD while the control group did not use, it can be concluded that the use of OLVD improves reading speed for learners with low vision. These findings are supported by (Ramani, Police & Jacob, 2014) study which established that the use of OLVD increases the reading speed by 37 words per minute and also improves reading accuracy and fluency. While other previous studies (Corn, Wall, & Bell, 2000) may have found contradictory evidence with respect to the findings of this study on the use of OLVD, Goodrich, Kirby, Wagstaff, Oros and McDevitt (2004) argues that manufacturers of OLVD are continuously finding new and better designs which reduce glass weight and increases efficiency of OLVD which may result to improved reading speed in our study.

Table 4.2: t-test Summary Results

	Intervention Group	*Control Group*
Mean Reading Speed (*Words Per Minute*)	118.90	102.57
Variance	75.69	113.16
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	2.91	
P(T<=t) one-tail	0.01	
t Critical one-tail	1.81	
P(T<=t) two-tail	0.02	
t Critical two-tail	2.23	

4.3.1 Modelling Reading Speed

The impact of the use and/or lack of use of OLVD (Group) on reading speed of learners with low vision was further assessed alongside other variables of interest such as distance visual acuity (DVA), near visual acuity (NVA), magnification of OLVD, gender, age and class of the learner. Multiple linear regression was used to model the significant predictors of reading speed. The model used in the study was;

$$Reading\ Speed = \beta_0 + \beta_1 DVA + \beta_2 NVA + \beta_3 Gender + \beta_4 Age + \beta_5 Class + \beta_6 Group + \varepsilon$$

Where β_0=mean reading speed for a learner with low vision, holding all other factors constant

β_i for i $= 1,2, \ldots 6 =$ regression coefficients, showing marginal contribution of the i^{th} independent variable in predicting the dependent variable (reading speed).

$\varepsilon =$ Stochastic errors in reading speed unaccounted for by the independent variables in the regression model.

The regression model used to fit the variables of study is significant (p=0.034<0.05) as presented in the analysis of variance (ANOVA) Table *4.3*. Out of the total sum of square of 1266.08, regression (using group as the only predictor) accounts for 517.52 (40.9%) variation which is significant (p=0.034<0.05).

Table 4.3: Analysis of Variance (ANOVA) table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	517.52	1	517.517	6.222	0.034[b]
Residual	748.56	9	83.173		
Total	1266.08	10			

The multiple R-squared for the above specified model ($R^2 = 0.76$) indicates that the specified set of independent variables accounts for 76% of variation in reading speed for a learner with low vision. Further model optimization analysis reveals that group (determined by the use or disuse of OLVD) accounts for 64% of variations in reading speed. The Table *4.4* details the summary statistics of the optimal regression model;

Table 4.4: Optimal Model Summary Statistics

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.639[a]	0.409	0.343	9.120

a. Predictors: (*Constant*), Group

The regression coefficients for the optimized model presented in Table *4.5* shows that the use of OLVD is a significant predictor (p=0.03<0.05) of reading speed for learners with low vision.

$$\text{Reading Speed} = \beta_0 + \beta_1 \text{Group} + \varepsilon$$

$$Reading\ Speed = 105.3 + 13.78(Group)$$

Therefore, the regression model; Reading Speed=105.3+13.78(Group) indicate that use of the OLVD increased the reading speed by 14 words per minutes.

Further, results indicate that DVA (p=0.61>0.05), NVA (p=0.39>0.05), magnification level of OLVD (p=0.57>0.05), gender (p=0.36>0.05), age (p=0.53>0.05) and class (p=0.46>0.05) of the learner played an insignificant role determining reading speed since of 76% accurate prediction of reading speed, 64% is accounted for by the use of OLVD. These findings are similar to the conclusions made by Lovie, Bevanm and Hein (2001) that reading speed among learners with low vision increases with the use of appropriate magnification device. This was further supported by Ramani, Police and Jacob (2014) who found that a majority of learners with low vision can achieve similar reading speed of their sighted peers when appropriate magnification is provided. Additionally, (Lovie et al, 2001; Ramani, Police & Jacob, 2014) established that near visual acuity (NVA) is a significant predictor of reading speed for learners with low vision. However, near visual acuity (NVA) was not a significant predictor of reading speed in the current study because the reading distance was conveniently adjusted to a suitable position through functional assessment.

Table 4.5: Optimal Regression Model

Model	Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	105.13	4.08		25.78	0.00
Group	13.78	5.52	0.639	2.49	0.03

Excluded Variables

Model	Beta In	t	Sig.	Partial Correlation
DVA	-0.174[b]	-0.537	0.606	-0.187
NVA	0.234[b]	0.900	0.394	0.303
Magnification of OLVD	0.371[b]	0.594	0.569	0.206
Gender	0.250[b]	0.967	0.362	0.323
Age	0.179[b]	0.660	0.528	0.227
Class	-0.207[b]	-0.772	0.462	-0.263

a. Dependent Variable: Reading Speed
b. Predictors in the Model: (Constant), Group

The group statistics presented in Table *4.6* also confirms similar results. There is a constant difference in reading speed of 16 words per minute between intervention and control group assuming either equal or unequal variances between the two groups ($p=0.016<0.05$). This further confirms that the use of OLVD improves the reading speed for learners with low vision by a mean of 16 words per minute, SD=5.61

Table 4.6: Independent t-test Summary Statistics

		t-test for Equality of Means				
		t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Reading Speed	Equal variances assumed	2.911	10	0.016	16.33	5.61
	Equal variances not assumed	2.911	9.62	0.016	16.33	5.61

To determine strength and the direction of the relationship between the significant study variables, correlation analysis between reading speed, group (use or disuse of OLVD), gender, age, DVA,

NVA and magnification of OLVD was conducted. Table *4.7* indicates a strong positive relationship between the use of OLVD and the reading speed. ($p=0.02<0.05$; $r=0.64$). The covariates had no signifiicant effect on the reading speed. ($p=0.29;0.18;0.07;\ 0.20;0.05>0.05$).

Table 4.7: Correlation Analysis Table

		Group	Gender	Age	DVA	NVA	Magnification OLVD	Reading Speed
Group	Pearson Correlation	1						
	Sig. (1-tailed)							
Gender	Pearson Correlation	-0.10	1					
	Sig. (1-tailed)	0.38						
Age	Pearson Correlation	0.21	-0.36	1				
	Sig. (1-tailed)	0.27	0.14					
DVA	Pearson Correlation	-0.565*	0.13	-0.08	1			
	Sig. (1-tailed)	0.03	0.36	0.41				
NVA	Pearson Correlation	0.08	0.45	0.34	-0.28	1		
	Sig. (1-tailed)	0.40	0.08	0.15	0.198			
OLVD	Pearson Correlation	-0.91**	-0.14	-0.07	0.66*	-0.24	1	
	Sig. (1-tailed)	0.000	0.34	0.42	0.01	0.24		
Reading Speed	Pearson Correlation	0.64*	0.18	0.30	-0.48	0.29	-0.51	1
	Sig. (1-tailed)	0.02	0.29	0.18	0.07	0.20	0.05	

4.4 Perception of Learners with Low Vision on the use of Optical Low Vision Devices for Reading

The analysis of the perception interview revealed that all the respondents found the OLVDs useful in aiding academic functions such as reading and writing. Specifically, the interviews revealed a positive attitude of learners with regard to the perceived usefulness of OLVDs. The results are presented in Table *4.8*.

Table 4.8: Perceived Benefit of using OLVDs

Perceived Benefit of Using OLVDs	**Percent**
Increased speed in reading and writing	85
Completion of examinations on time for the first time	67

Easy completion of class assignment and reading task	67
Boosting self-esteem and self-efficacy	50
Reduced eye irritation	50
Improved magnification of the reading text making reading easy and enjoyable	33

Regarding the ease of use, all the participants found that the use of OLVDs especially the spectacles mounted are easy to use, store and move around with in the school as compared to other devices such as stand magnifier, handheld magnifier and the telescope. They described the OLVDs as being easy to use and comfortable on the eyes, for instance, one learner responded that *"Inafanya Kubwa...sitoi machozi na macho hayana uchungu…." (It makes big ... I do not tear and eyes have no pain anymore).* All the respondents preferred using the OLVDs especially the spectacles mounted as they perceived them as easy and very comfortable to use. The reason why the learners described the OLVDs as being easy is linked with the stated benefits of use of OLVDs such as increased speed in reading and writing as seen in the response of a learner who said, *"nasoma haraka haraka…. (I read faster faster...)* with lots excitement in the voice. Most of the participants didn't report any major challenge in the use of their preferred optical device which can be attributed to the one week training they received prior to the use of the device. The training focussed on positioning of the device, eye and head movement, maintenance and cleanliness of the device.

When participants were asked to state if they wished to continue using the OLVDs, all the participants were affirmative of their intention to continue using the OLVDs. The use of an optical device is perceived as the easiest device to use and is considered most reliable. Based on the Technology Acceptance Model, the results suggest that the OLVDs are useful and easy to use, hence the intention to adopt and continue using the device. This finding is consistent with some of the verbal statement made by participants such as:

Interviewer; You have used low vision devices for some time now, have they been of any help to you?

Respondent 1:

"…they have helped a lot, a lot. Before I used to read with eyes, I used to read but after, even if it is an exam when I walk out of exam room, my eyes would start tearing, now am okay, I do not even feel pain.
In my assignments I am helped… I used to work slowly now I have improved am not the last one in class. I have improved I leave early. In reading I used to struggle I read and eyes do not feel tired…"

"I used to do my assignments so slowly and used to come out of the class as the last person during exams, these days am able to finish early and am never the last to finish my work as I used to there before."

"In reading, I don't struggle any more as I used to there before, I do read well and even read again whenever I don't understand what I have read during the first attempt."

“I have not experienced any problem when using the OLVDs and I would like to continue using them for my studies. They should not be changed for these are the best for me as they enlarge the reading texts very well.”

Respondent 2; on the perception of the usefulness of the optical device said

“I have been using them during exams like today I was able to finish the examination early. In reading and writing, I have been doing very well. I have been faster in writing exercises”

“My eyes have not experienced any problem when using the OLVDs like it used to be before I started using them”

“I would like to continue using them because they have been helping me more than when am using naked eyes.”

Chapter 5 **CONCLUSIONS AND RECOMMENDATIONS**

5.1 Introduction

In the previous chapter, the data was analysed, results presented and discussed. This chapter presents the summary of the findings and makes conclusions and recommendations of the study. This study was designed to study the influence of optical low vision devices on reading outcomes among learners with low vision. The objectives were to establish the influence of optical low vision devices on reading speed among learners with low vision and find out the perception of learners with low vision on the use of optical low vision devices for reading. The research was done in Thika School for the Visually Impaired, in Kiambu County, Kenya. Learners with low vison were included in the study. The conclusions and recommendations of the study are given below.

5.2 Conclusion

As the prevalence of learners with low vision is increasing and debate on the most appropriate literacy media is raging, the best possible vision enhancement devices are important to enable learners with low vision access quality and meaningful education. In this regard, the study arrived at the following conclusions based on the research findings:

The study concluded that provision and training on the use of optical low vision devices is an effective starting point. The unique contribution of this study to the field of education for learners with low vision, is that the benefit of the use of OLVD is a simple and easy strategy of enhancing reading outcomes.

The study also concludes that early identification and assessment, provision of appropriate OLVD improves reading outcome for learners with low vision. In addition, the results of this study showed that training on the use of the devices contributes enormously in reading performance. Therefore, provision of OLVD must be accompanied with training on the use.

5.3 Recommendations

When the reading speed of learners with low vision in intervention group improved, it is evident to indicate that optical low vision devices indeed can improve reading speed. The mean speed for the control group was 103 words per minute while that of the intervention group was 119 words per minute. The comparison between the learners in the intervention group and those in the control group indicated superior performance with respect to speed and number of errors committed. The fact that intervention group improved in reading speed after using optical low vision devices agrees

with earlier research by Bracher and Matta, (2017), who averred that training persons with low vision on special reading techniques using OLVDs improve reading performance.

The key question of this study was whether the optical low vision devices improves reading speed in learners with low vision. This question was tested by experimenting with two groups of learners; one as intervention and the other as control group. Based on the results, a number of recommendations have been given for schools and other stakeholders

5.3.1. General Recommendations

Early intervention by use of optical low vision devices is a significant predictor of reading speed in learners with low vision. It is clear that providing adequate magnification to compensate for reduced visual functioning would be the most important educational intervention of the present study.

Early identification and assessment should therefore be encouraged. Children with low vision should be identified as early as possible and appropriate interventions put in place to improve the children's reading speed. Parents, teachers, care givers and therapists should be trained in early identification and intervention so that they can take active role in the early intervention.

5.5.2. Recommendations to the Ministry of Education

The ministry to acquire enough OLVD for early intervention so as to enable children with low vision to maximize their potential and increase their self-esteem. Schools struggle with getting OLVD, therefore equipping the schools with the right devices will improve the reading speed of learners.

5.3.3 Recommendation for Further Research

Lack of research on reading performance in children with low vision is widely acknowledged, the present study sheds some light on the reading performance of learners with low vision. Therefore, it is recommended that a future study on different aspects of reading by learners with low vision. For example, special tests should be designed to measure reading performance in regard to speed, fluency, comprehension before and after provision of OLVDs and training in reading. In addition, a study should also be carried out to establish the effect of an intervention when evaluating reading interest, reading duration and visual fatigue as outcome variables in addition to reading rates.

Lastly, it is worth nothing that prescribed optical device in the present study was spectacle mounted magnifiers. However, there exist other devices such as stand magnifiers, handheld and electronic

magnifiers. In that regard, another study should be carried out to determine the most ideal device for different learners.

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