AN EXPLORATION AND DEVELOPMENT OF TEACHING RESOURCES TO BETTER INCLUDE STUDENTS WITH VISUAL IMPAIRMENT IN SCIENCE AND MATHEMATICS CLASSES IN SOUTH-WESTERN NIGERIA: AN ACTION RESEARCH STUDY

By

SARIAT AJIBOLA ADELAKUN

A thesis submitted to

The University of Birmingham

for the degree of

DOCTOR OF PHILOSOPHY

School of Education

University of Birmingham

July, 2016

ABSTRACT

The study was concerned with access to science and mathematics curricula by students with visual impairment (SVI) in South-Western Nigeria. The main study adopted an action research approach.

Six initial stakeholder ‘search conferences’ were organised to understand the nature and extent of the problem. They revealed evidence of inadequate accessibility to science and mathematics education by SVI due to unavailable resources and personnel. This led to the development of teaching resources and approaches (‘STEM Kit’ and the use of ‘Talking LabQuest’) and the trialling of these approaches in two selected study schools. Data were collected through classroom observation and teacher and student interviews.

Findings show that the approaches enabled access of SVI to science and mathematics at a comparable level with their sighted peers, which brought about immersion in, and engagement with learning. With the multisensory teaching resources, SVI and classroom sighted teachers learn and teach with reduced specialist teacher involvement. The intervention positively challenged local views and practice regarding curriculum access and SVI and offers examples for improved provision of relevant resources and training for staff to better support SVI independence and inclusion. This study showcases the uniqueness of action research in empowering all participants to bring about change.

DEDICATION

This thesis is dedicated to the Almighty Allah, THE POWER BEHIND EVERY SUCCESS who deserve all praises and adorations.TO HIM I OWE WHAT I AM TODAY

ACKNOWLEDGEMENTS

I am particularly grateful to The Almighty Allah for seeing me through the mountains and valleys encountered during this programme. Wa kanallahu ala kulli shaein muqtadiro.

My special appreciation goes to my supervisor Dr Graeme Douglas for his valuable support and constructive feedback which resulted in this thesis. His patience and encouraging style of supervision injected life in my programme which was nearly extinguished.

My appreciation cannot be complete without appreciating the Nigerian government for making funds available for me to pursue PhD through Tertiary Education Trust Fund [TETFUND]. The entire management of the Federal College of Education (special), Oyo also deserve much appreciation for granting me a study leave with pay.

I owe unquantifiable appreciation to my parents whose support and encouragement drives me this far. My jewels [Taofiqiya, Aonah, Barakah] deserve recognition as sources of joy that lubricates pains experienced during this programme. Much love for my grandson, namesake, Mubaarak Ajibola Tokunbo Lucky for being my companion and comforter during the period of writing this thesis.

My husband, Tahir deserve much appreciation for his patience for the long period of staying apart. I say a big thank you

The unquantifiable love, support and understanding displayed by my parents Alhaji and Alhaja Hamza Adegbola deserve much recognition. They are everything to me. All my siblings deserve appreciation especially Balqis Adebayo and Mutiu who covered my absence in vital areas. Muizdeen Abu Mubaarak plays a prominent role worthy of appreciation. I also appreciate the support of Abu and Umu Haleemah Raji on vital points during this programme.

Umu Barakah, Umu Hassan, Umu Fatimah in Sheffield deserves appreciation and all members of Nimab in Birmingham. Special appreciation goes to Abu and Ummu Hamna, Abu and Ummu Tahir Tijani and our flat mate in Sheffield (Abu and Umu Fridaos) for their support. Alhaji Alabi Muritadha, Mrs Aminat Abdulsalam, Paul Olaoye and Abubakar Mohammed McJesus contributed in no small ways to the success of my programme. Wasilat and Khadijah from South Africa, Abu and Ummu Ilyas were so helpful.

I appreciate all the stakeholders in all the states that participated in this study, the commissioner for education, Chairman of SUBEB, director in charge of special education, Staff and students in the mainstream schools who were participants at the search conference and those of the study schools. Without the cooperation displayed the study would not have been possible.

I am also grateful to others too numerous to mention for their contribution in various ways to the success of my programme. I appreciate Tim Davies of the clarity and precision for proof reading the full thesis.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

GLOSSARY

AR:	Action Research
AT:	Assistive technology
ECC:	Expanded Core Curriculum
ILAB:	Independent Laboratory Access for the Blind
JSS:	Junior Secondary School
MAN:	Mathematical Association of Nigeria
RCT:	Randomised control trial
SSCE:	Senior Secondary School Certificate Examinations
SSS:	Senior Secondary School
STAN:	Science Teachers Association of Nigeria
STEM:	Science, Technology, Engineering and Mathematics
SUBEB:	State Universal Basic Education Board
SVI:	Students with Visual Impairment
TLQ:	Talking LabQuest
TVI:	Teacher of visually impaired
UBEC:	Universal Basic Education Commission
VI:	Visually impaired / visual impairment
WAEC:	West African Examination Council

CHAPTER 1. INTRODUCTION

1.1. Chapter overview

This chapter presents the introduction to the research in three sections. The first section elucidates the context of the study which includes the settings and background that led to this study taking place as well as the rationale for the research. The second section includes the aims of this research followed by a short description of my experience during the research that reflected changes to my initial proposal. The third section presents the structure of the thesis which serves as a guide and summary of the various stages of the study.

1.2. Study context

1.2.1. The settings

Nigeria is one of the 54 Africa countries. Africa is the second largest and second most populous continent. Nigeria is situated in the western part of Africa, shares borders with the republic of Benin to the west, Niger in the north, Chad and Cameroon in the east and the Gulf of Guinea in the south. Often referred to as the ‘giant of Africa’, Nigeria is the most populous nation in Africa and got her independence from Britain on 1st October 1960. Currently, Nigeria has a population of 182 million people, making Nigeria the 7th most populous nation in the world. Nigeria is divided into 36 states and the federal capital territory and is arbitrarily divided into six geo-political zones for administrative purpose by the government (North East, North Central, North West, South East, South South and South West).

This research was conducted in the South Western geo-political zone which comprises of Lagos, Osun, Ogun, Oyo, Ekiti and Ondo States. Each of the states is governed by an elected governor who administers the state with some autonomy. Education, health care, and infrastructure differ from state to state.

1.3. The Background

People with visual impairment form a substantial percentage of the world's population (World Health Organisation, 2012) and the burden is not distributed uniformly throughout the world, nor is it uniformly distributed across age groups or gender (Akanji, 2009). Over 1.4 million of the world's children are estimated to have a form of visual impairment (Ezegwui et al., 2003) and the least developed regions carry the largest share (Resnikoff et al*.,* 2004). There is no accurate data concerning visually impaired people in Nigeria (Kyari et al., 2008; Akanji, 2009; WHO, 2012). However, there has been health care research carried out in specific locations in Nigeria which give an idea of the prevalence. Muhammad et al. (2010) estimated a prevalence of 1.2% in a local government in Sokoto state in Nigeria. Their work also showed that the impairment affected more boys than girls and was higher between ages 11 and 15. In contrast, Abiose et al. (1994) had a much higher 3.3% prevalence in Kaduna State. In the South-Western states, Ajaiyeoba et al. (2006) found 1.48% and 15.5% prevalence in two different parts of the zone, in two cross-sectional studies that involved primary and secondary school students. The actual prevalence is not known, considering the variable figures obtained by the research studies. The factors responsible for the variation are also not known.

In Nigeria, people with visual impairment have entered career fields in arts and social science (Akanji, 2009). However, they are rarely found in science disciplines (Ayoku, 1998, 2006; Adediran and Oluokun, 2007). This appears to have been the case in many parts of the world until recently, when the advent of assistive technology devices has enabled visually impaired people to find it increasingly easy to pursue Science, Technology, Engineering and Mathematics (STEM) subjects beyond compulsory education (Sawhney, 2014). Although many factors contribute to the choice of career of students with visual impairment, the lack of independent and fulfilling experience in science laboratory classrooms has been widely acknowledged as a major inhibition to learning and participation in science (Rutherford and Ahlgen, 1990; Scadden, 2005; Supalo, 2010). Apart from choosing science as a career, it is argued that engagement with science and gaining a scientific understanding has broader benefit (Supalo, et al. 2008). Such engagement and understanding help people take care of themselves, eliminate misconceptions and live independently in this world dominated by products of science and technology.

Mathematics is also considered important, given its indispensable role in full participation in society (Morris, 1981). Failure in mathematics is associated with general failure in school (Lörcher, 1989a) and a life-long feeling of inferiority (Buhagiar, and Tanti 2011), because mathematics comprises ‘use-values’ of various economic and domestic practices (Dowling, 1998). Therefore, denying anyone access to mathematics could be considered an injustice (Lörcher, 1989b).

More specifically, a visually impaired child who cannot learn spatial relationships incidentally (as is arguably the case for sighted children), needs to acquire spatial concepts like shape, size, distance, fraction which are important concept in daily living activities.

In the National Policy on Education (FRN, 2004) the Nigerian government made Basic Science compulsory at the basic education level (ages 6 to15) because of the important role played by science in the technological development of the nation. It is also compulsory for students at senior secondary school to be offered and register at least one science subject in the Senior Secondary Certificate Examination (SSCE) examinations [West African Examination Council (WAEC) & National Examination Council (NECO]. A good understanding of basic science at the basic education stage underpins students' interest and performance in science subjects at the senior secondary school and beyond, because the basic science curriculum includes foundation topics for all the areas of science. The Nigerian government also directed Nigerian Universities and other tertiary institutions to admit students in a 60:40 ratio in favour of science-related disciplines (FRN, 2004). According greater importance to science is one of the recognised routes to achieving 'Vision 20: 20 20' (Eneh, 2011), which lays out the Nigerian Government's aspiration to be among the 20 leading global economies by the year 2020 (FGN, 2010).

Similarly, mathematics is compulsory throughout the basic education and senior secondary school. Failure in mathematics is usually a yardstick to determine promotion from one class to another during this period. Also, many courses require all applicants applying to tertiary institutions to take mathematics as part of the Unified Tertiary Matriculation Examination (UTME), and in fact, all year one university students have a compulsory mathematics course that must be passed to qualify for any degree in Nigerian Universities. Denying anyone access to mathematics education can have a profound impact upon opportunities in later education and life.

A review of research in science teaching to students with visual impairment (SVI) in Nigeria showed a low enrolment of students with visual impairment in science subjects in school certificate examinations (Giwa and Ogunkunle, 2004; Abilu, 2005 and Adelakun, 2006). For instance, many secondary schools mainstreaming students with visual impairment in South-Western Nigeria usually exempt them from mathematics and parts of science lessons, based on the misconception that it is not possible for blind students to do these subjects (Abilu, 2012). This ultimately affects what the SVI studied after secondary school and the level of independence attained in their day to day activities, which according to Rowe (2014) diminishes their access to employment and leads to dependency.

Analysis of the enrolment and results of students in the West African Examination Council (WAEC) supports these arguments. For example, in 2005, 2006 and 2007 WAEC reports no SVI was registered for core science subjects (Physics and Chemistry), and the few that registered for Biology performed poorly. The report also shows that those who register in some schools absent themselves from the examination because registering the course was just to make up the compulsory subjects for all students. Within this period, less than 50% of the 36 states registered SVI for mathematics. According to Abilu (2012), 75% of schools mainstreaming SVI exempt them from taking part in mathematics and science.

However, studies by Hill (1994, 1999) and Adelakun (2006), showed that students with visual impairment (SVI) performed equally well with their sighted peers when taught selected topics with adapted materials. They are also known to perform well in non-science subjects enrolled in WAEC (Abilu, 2012). In support of this assertion, WAEC reported in the *Vanguard* newspaper of 22nd December 2012 that “Blind students performed better than those without sight problems as 46.93 percent of 49 students that registered for the examination obtained five credits including English Language (p.8).” Blind candidates do not sit for Mathematics and Science practical in WAEC examinations (Atinmo, 2007)

As a way to include the SVI in science education, Abilu (2012) recommends the provision of alternatives to practical lessons for learners with visual impairment. This, to me, is unnecessary when resources that can enable SVI to participate and perform practical science independently are already available, and the preparation of basic independence skills (e.g. orientation and mobility, independent living skills) to prepare and support them while doing science are also in place (or should be). Instead of providing alternatives to practical lessons, I hoped that the introduction of science teaching resources (such as ‘Talking LabQuest’ [TLQ] and special STEM Kit as discussed elsewhere in the thesis) would enable the participation of SVI in basic science and could initiate a new direction towards making science and mathematics more accessible to students with visual impairment in Nigeria.

There is no reason why a person with visual impairment should not be given the same opportunity to access all areas of the curriculum (including all aspects of science and mathematics). Children should have equal access to a full education irrespective of their disability. This is fundamental to an ‘inclusive education’

Furthermore, the contribution of prior knowledge in learning which the sighted acquire casually most of the time is also important. Incidental/experiential learning, as it is often called, is very important to all learners. All children need basic independence skills, especially the VI children. Because they find learning these skills hard to do, the teaching of additional curriculum / expanded core curriculum (ECC) areas is needed, and is important as a substitute of the prior knowledge which, unlike the sighted, cannot be learnt casually by SVI. “Without gaining access to the general education curriculum, students cannot learn it” (Allman and Lewis, 2014 p. xiii). Therefore, for SVI to be prepared for, and supported while doing science they need to acquire ECC skills. These, according to Allman and Lewis (2014) are:

- ❖ Compensatory access: skills that must be learnt by the SVI to access information about the world, to communicate with the world and be successful in school.
- ❖ Sensory efficiency: skills that involve effective use of input derived from the senses, this includes learning how to use visual, auditory, olfactory, gustatory and tactile skills to function efficiently. This would entail using their remaining vision (if it exists) along with other senses.
- ❖ Assistive technology: technology has become an integral part of life for all, and more importantly it enables SVI to access information, to communicate and to use facilities to enhance personal productivity.

- Orientation and mobility: skills to learn about one's environment and how to move safely, effectively and as independently as possible.
- Independent living: skills surrounding the daily demands of life which are learnt incidentally by the sighted, such as personal hygiene, time management, and eating habits.
- Social interaction: skills needed to participate in social interaction such as body language, social communication, appropriate conversation patterns, cooperative skills, and developing and maintaining friendships.
- Recreation and leisure: skills needed to participate in recreation and leisure such as games, physical activities, health and fitness, leisure activities and team sports. These skills are needed for good health and a happy lifestyle.
- Career education: skills needed to prepare students for all the roles they will likely play in their life. SVI may have difficulty in visually observing professionals in action in their roles. They may therefore need to learn how to develop the ability to make an informed career choice, and how to express their personal interest.
- Self-determination: this includes skills that promote independence and successful functioning in society (Hatlen, 2003; Sacks, 1996). Wolffe and Sacks, (1997) consider self-determination as a predictor of future success. Awareness of individual rights and responsibilities, problem-solving and goal-setting, and self-advocacy are examples of skills that portray self-determination.

In addition, Cambourne (1995) listed some conditions that need to be met for learning to take place: immersion, demonstration, expectations, responsibilities, usage/employment of knowledge gained, approximation, and response. There is an emphasis here that engagement will likely improve when the last five conditions are present. These seven conditions cannot be satisfied by the passive attendance of learners in mathematics and science lessons, and certainly not through *non*-attendance. “Immersion and demonstration must be accompanied by engagement” (Lent, 2006: p 4) for meaningful learning to take place. My belief was that such engagement can be achieved if appropriate teaching resources and strategies are introduced into the Nigerian mainstream classroom (specifically the TLQ and Special STEM Kit developed in this research) – teaching approaches which involve learners interacting with materials, solving problems in classwork and assignments, and having hands-on experience in the laboratory or the field; where learners are required to be immersed in the learning process and to demonstrate their engagement. For these reasons, it seems to me that Cambourne’s theory can best be used to expound the need for SVI to participate in learning mathematics and practical science.

1.4. Rationale for the study

As noted, in recent years, an increasing number of people with visual impairment in Nigeria have gained access to higher education in non-science disciplines (Adediran and Oluokun, 2007), but very few blind and low vision students have successfully been educated in science during and beyond secondary school (Abilu, 2012). This has led to the low representation of people with visual impairment in the field of Science Technology Engineering and Mathematics (STEM) in higher institutions and in science-related employment. In developed countries, like the US, the development of assistive technology devices has over the years increased the participation of visually impaired people in STEM subjects in higher education. This has produced academics in diverse science fields (Hobson and Townsend, 2010; Supalo, 2013).

In Nigeria, the National Policy on Education (FGN, 2004) emphasised equalising educational opportunities for all, irrespective of disabilities. Although education policy in Nigeria suggests that Basic (general) Science should be accessible to all, by making it compulsory up to junior secondary school level, there has been little provision for, or attention paid to, facilitating the learning of science by SVI in regular classes in mainstream schools. One major difficulty for the SVI in learning science is that science is traditionally seen as a visual subject which requires students to observe changes and reactions.

Using effective strategies and resources may enhance interest, and increase or induce participation in science subjects. It is hoped that this would encourage more SVI to take up science at higher levels. This need is particularly desperate in Nigeria where there is a very large population with some degree of visual impairment, there is therefore much justification for well-developed and tested resources and techniques to be used in schools to make science more accessible for the visually impaired, and thus increase the number of people with visual impairment taking up science at higher levels as well as improving their independence and understanding of science in their day-to-day activities.

The reason I focus my attention specifically on the teaching and learning of science is primarily because of the relevance of science to the visually impaired (Adelakun, 1998; Resnikoff et al., 2004), as it enables them to take care of their own health (Supalo et al., 2006), understand the importance of sanitation and hygiene, and to eliminate misconceptions and superstitions (Coville, 1932; Fraser, 2008; Supalo et al, 2009). Another reason for my interest in the teaching and learning of science to the visually impaired is my background as a lecturer at a Special Teacher Training College. Having spent over twenty-five years in the college, I have not seen any instance of SVI being admitted to a science course. Nigerian pupils living in a culture that is surrounded by the products of science need science education, not only to obtain certificates but also to be able to adjust to the effect technological advances have on their daily lives. For the SVI, it means achieving independence. Thus, science education can serve as a route to independence for SVI.

Furthermore, in my evaluation of the teaching of Integrated Science to SVI in junior secondary schools (part of my Master's degree project) in 1993, I recorded inadequate relevant facilities to teach SVI science. However, in recent times, there has been much progress in the use of quite affordable specialised toolkits for teaching science to SVI, such as the ones listed in Supalo et al, (2007) explained under resources for teaching science and mathematics to VI in the literature review section.

Currently, there are relatively few studies that have evaluated the effectiveness of these teaching and learning tools in the United States (Supalo, 2010). I am aware that there has been much progress in recent years in the use of quite affordable specialised toolkits for teaching science and mathematics to SVI, but such advancements seem to be slow in coming through to Nigeria. One toolkit that has been extensively evaluated is the Talking LabQuest (Supalo, 2012; Supalo and Kennedy, 2014;), but this evaluation was performed by the developer himself (Cary Supalo). Moreover, most of his studies were carried out in developed countries. There is a lack of empirical research undertaken to evaluate the impact of these specialized toolkits in developing countries. Therefore, this study is an attempt to investigate the problem and evaluate the potential of resources for bringing change to the situation.

Cary Supalo, a blind academic himself, recommends that these resources should be tested more widely in other parts of the world. My study, therefore, represents an independent evaluation of a tool that has been claimed to be effective by the developer. This will be an opportunity to try out these resources in Nigeria. If used in conjunction with the STEM kit (which was conceived during the research and it is discussed in detail in chapter 4) for calculations and graphs, can they be shown to be more effective than teaching resources already available in the country? In which case, recommendations and considerations can be made for their wider use in junior secondary schools in Nigeria. This is one of the rationales for my study. The cost of the TLQ and the STEM Kit is also considered to be affordable to government and schools mainstreaming students with visual impairment in Nigeria.

In addition, I have been inspired by many blind or visually impaired people who have studied STEM courses. Their experiences, education and successes offers evidence and inspiration that SVIs can engage in, excel at, and contribute to the

STEM subjects. Particular individuals who have inspired me are: Cary Supalo who studied Chemistry to PhD level and still teaches chemistry in the University; Lev Semenovich Pontryagin was a Soviet mathematician of great repute and was one of the greatest mathematicians of the twentieth century supervising many PhD students in Moscow State University; Geerat J Vermeij is an evolutionary biologist and palaeontologist and Distinguished Professor of Marine Ecology and Paleoecology in the Geography Department of the University of California; Emmanuel Karemi Dinglip, a Nigerian who studied Mathematics at the University of Jos, Nigeria.

These role models succeeded even though they faced many barriers. This suggests that learners with visual impairment in Nigeria can also be successful in mathematics and sciences.

1.5. Aims of the research

Overtime, the initial proposal for my thesis, of devising strategies of enrolling sensory-impaired students in sciences in Nigeria, has developed. The eventual study, which is the key presentation in this thesis, broadly explored the extent of the problem, and evaluated the impact of using Talking LabQuest and the self-developed STEM Kit on the participation of SVI in basic science and mathematics in junior secondary schools in South-Western Nigeria. Specifically, the study examined these educational interventions and:

(a) Students’ participation in science and mathematics;

(b) Students’ level of independence during science and mathematics lessons;

(c) The influence of SVI competency in the expanded core curriculum (ECC) on SVI participation and independence in basic science and mathematics activities; and perhaps the influence of the activities on their ECC competency;

(d) The perceptions of all students (including sighted children) regarding the Talking LabQuest and self-developed special STEM Kit as learning tools; and

(e) The perceptions of teacher(s) regarding the use of the resources as teaching tools.

1.6. Researcher's perspectives

I studied BSc Chemistry during my undergraduate days, and I have worked in a Federal College of Education (Special) in Nigeria for 27 years. I had training in Special Education when UNESCO sponsored staff in my college for the Master's degree in special education delivered by the University of Birmingham between 1993 and 1994. As a lecturer in a special education school, we prepare teachers of learners with special educational needs (SEN). Our trainee teachers experience teaching practice in special schools/mainstream schools once before graduation, and while on teaching placement staff will visit schools to supervise them. My exposure during such supervision ignited my intention to conduct this study. Before now, I have conducted up to five research studies on the problem of access to science for learners with visual impairment. In 1993, I evaluated the special resources in schools for the blind in three states in Nigeria. I found that adapted resources are scarce and the SVI are not taught mathematics, and that they were exempted from producing diagrams and calculations in science subjects. In 2006, I evaluated the performance of learners with visual impairment in science using resources designed or adapted by the researcher, and found that they performed similarly to their sighted peers. Among others, there was a publication in ‘Ilorin Journal of Education’ about the importance of scientific skills and attitudes in the education of SVI.

1.7. Definition of terms

Some terms are central to the research and are used in a particular context, thus, they need to be defined for the reader.

Assistive technology [AT]: “Any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities. It does not include medical devices surgically implanted or the replacement of such devices” (IDEA, 2004:11).

Students with visual impairment [SVI]: Learners with impaired vision who are braille readers, whose vision is not enough to support access to print. It is further explained in Chapter 2

Junior secondary school [JSS]: Junior Secondary School, the first three years spent after primary school in Nigeria. That is the early part of secondary school. It is the last three years of the basic education. Six years’ primary education plus three years of junior secondary makes the 9 years of compulsory education as stated in the Nigeria National policy on Education. The administration is under each of the state governors. Usually, there is a joint final JSS 3 examination in most of the states.

Senior secondary school [SSS]: The last three years spent in secondary school after the compulsory basic education. The administration is under each state government but there are also national and international examinations [National Examination Council (NECO) West African Examination Council examinations which represent the senior secondary school certificate examination [SSCE]

Participation: A social phenomenon, an act of active involvement in class activities, doing what the sighted peers are doing in response to the teacher's instruction/directive. It consists of active involvement such as manipulating resources, asking questions during the process, taking turns in group activities. It is described in this study along with independence, the accomplishment of tasks and engagement with classroom/laboratory activities.

Independence: A very broad term which connotes different meanings depending on context. In the context of this study, independence means a situation whereby SVI do classroom tasks on their own with limited support from their peers and teachers. For example, the arrangement of the tiles on the metallic board without assistance and solving problems in classwork on their own with minimal help, similar to their sighted peers. This also means manipulating resources on their own during practical activities.

The accomplishment of tasks: A task is accomplished when it is done correctly within a specified period. It is also context specific. Therefore, with regard to this study, a task is considered accomplished by SVI when it is done comparably like their peers. This refers to a level of performance of SVI in classwork/laboratory activities given by the teacher during the period of observations.

Engagement: This term is also context specific, in this study it refers to a situation whereby a SVI is seen manipulating resources in response to teacher's instructions, and taking part in all classroom /laboratory activities either on their own or in group with their peers.

Support: In this study, any help rendered to SVI by the TVI, their classmates, or subject teachers during lessons or laboratory activities is considered support. It also includes using special resources or assisting SVI to understand/participate in class activities, either working together after school with peers or teachers on subject topics or on ECC skills.

Teacher of visually impaired [TVI]: Teachers with a qualification in education of visual impairment from a Nigeria College of Education or University. TVIs monitor and organise the functioning of the resource room to support SVI in a mainstream school.

Science Technology Engineering and Mathematics [STEM] Kit: This refers to the name of the researcher-designed Kit evaluated along with TLQ in this study. It is the copyright name and Trademark of the product (an extension of the Kit evaluated in this study). It is further described in chapter 4.

Mainstreaming: This term is used interchangeably with 'inclusion'. It refers to accommodating special needs students in the same school and classroom with upgraded facilities giving SVI equal opportunity as their sighted peers. It is different from "Integration" which involves educating special needs students in the same school and classroom without emphasis on adjustment/upgrading of facilities.

Inclusion: same as mainstreaming.

Talking LabQuest [TLQ]: One of the resources evaluated in this study, it is designed by Vernier Software and Technology for teaching hands-on science to students. This is the version that is adapted by Cary Supalo for enabling access of laboratory science to SVI like their sighted peers. It is marketed by the Independence Science Company USA. More information about TLQ is provided in Chapter 4.

1.8. My PhD Journey

The decision to pursue this study arose from a long-term observation of practices in mainstream schools during annual teaching practice supervision as a lecturer in the department of Integrated Science, Federal College of Education, (Special) Oyo. I had carried out personal research into adapted resources available in mainstream schools for the SVI in South-Western Nigeria and found out that there were inadequate provisions for the SVI in those schools. In terms of practice, I had tried to develop resources to bridge this gap. For example, I developed adapted tactile models to teach the digestive system, and found that the SVI performed even better than their sighted peers in the class that was involved in the study. Similar findings were obtained when tactile models were used for teaching the periodic table and some other topics in chemistry to SVI.

In a nutshell, a broader problem of access to the science curriculum and teaching by SVI in Nigeria was identified from my experience as a teacher trainer. I had a keen interest in bringing about change, emancipating the SVI from the perceived problem and injustice.

I started my MPhil/PhD research with a proposal titled ‘Innovative strategies for enhancing enrolment of sensory impaired students in sciences in Nigeria’. However, considering that my previous research was more on SVI I shifted my title to: ‘Innovative strategies of involving SVI in Sciences in Nigeria’. An exploratory study was conducted to examine and reconfirm my observation and concern. This is reported in Chapter 3.

The exploratory study reaffirmed the existence of the problem. My firm decision to find a solution to the problem led me to further literature search on the issue of access to science to the SVI in countries outside Nigeria (the UK and the USA especially). I also visited two specialist schools in the UK and informally observed science teaching.

At one school I observed a practical class of only four SVI taught by a science teacher with the support of an assistant. The experiment was on determination of the temperature of cooling liquids. Each student was provided with a tray which served as working space where hot liquid, test tubes in test tube racks, and a talking thermometer were placed. Each student had a “BrailleNote” with him/her (and BrailleNote is a small portable computer with a refreshable braille display). Two of the SVI worked independently while the remaining two worked with greater assistance from the teacher and the assistant. The BrailleNote was programmed to alarm at 2-minute intervals which prompted the student to press the thermometer to voice the reading of the temperature at intervals. Thereafter, the readings which were earlier stored on the BrailleNote was transferred to the desktop computer placed on one side of the laboratory. I saw samples of past graph plotted by the students and few other talking tools, and some tactile models displayed in the laboratory.

At the other school, I spoke with some students and staff and I saw some talking tools (thermometer, kettle, weighing balance) as well as models and adaptation tools.

There was no talking LabQuest in the two schools and there was nothing like the special STEM kit. While the observation was interesting and I was encouraged that these students were accessing the curriculum, I wasn't completely satisfied with what I found in the two schools visited. Further reading and attendance at the AER conference in San Antonio, Texas, USA led me to other possible solutions, which were eventually evaluated in Nigeria.

The Talking LabQuest is designed for data collections in STEM subjects. Though a more expensive technical solution, some quantities were purchased with few relevant sensors at the AER conference. The desire for a less expensive tool that could enable the SVI to participate in calculations and drawings aspects of science and mathematics lessons like their sighted peers when taught by the sighted teachers led to the design of the special STEM kit. I introduced and evaluated the two teaching resources in collaboration with the stakeholders in an action research study. This resulted in the thesis presented here which is outlined in the next section.

1.9. Outline of the thesis

This section presents the outline of the structure of the thesis (beyond this introductory chapter). Each chapter is briefly introduced to serve as a guide for readers.

1.9.1. Chapter 2: Literature Review

The chapter presents relevant literature on the key concept of the study, starting from the definition of visual impairment and what it means in this study. I describe the Nigerian educational system and how it relates to the USA and the UK, to justify the usability or relevance of resources produced in the USA to Nigeria educational system. Science teaching in Nigerian schools is appraised and especially science teaching to learners with visual impairment; the same is done for mathematics teaching in Nigerian schools. The importance of science and mathematics to learners with visual impairment is also discussed. There is a dearth of literature generally on the teaching of science and mathematics to learners with visual impairment in Nigeria; however, available literature was reviewed. There is a brief review of resources available for teaching science and mathematics to the SVI, which ends with an appraisal of the critique of the resources and relevance of such resources to the Nigerian context. The chapter goes on to present the expanded core curriculum (ECC) for learners with visual impairment. The ECC approach argues for the importance of independence beyond academic outcomes. Some of this means that the students must have prerequisite qualities before working independently in the science lab, but also they can learn these things through participation in hands-on science work.

Introduction and appraisal of the resources evaluated in this study are also discussed. The last part of the literature review focuses on the learning theory which guided this study; Cambourne's learning theory and its application to the study is reviewed. Cambourne argues that science is best learnt through the practice of scientific enquiry and therefore we must ensure that SVI have access to the practical work, which leads to my interest in TLQ.

1.9.2. Chapter 3 Exploratory Study

The exploratory study was necessitated to ascertain the current status of access of science to SVI. The chapter presents the aims, research questions, procedure, findings, and analysis of the exploratory study. There are reflections on the findings, and there are also reflections on the methodology (design and method) adopted.

1.9.3. Chapter 4 Methodology

The main study is based upon an action research (AR) cycle. Chapter 4 describes the methodology of the AR cycle that was adopted. The chapter commences with the theoretical and philosophical underpinnings behind the choice of the AR design for the study. The study was neither placed within positivism or interpretivism; since it involves emancipation, the focus has been on changing practice. A 'critical paradigm' has been adopted; it shares some features with interpretivism but goes a little further.

Within the AR design, the detailed description of the methods of data collection adopted is presented, indicating the relative merits of the methods and why have been selected. The stages involved in the AR are also highlighted. This is followed by descriptions of the procedure of implementation of the methods following the stages of the AR cycle. Research Accuracy, Credibility, and Dependability are also discussed. The process of data analysis used is also described. Manual analysis of data is combined with software analysis using NVivo.

This is followed by a discussion of the reasons, benefits and process of triangulation in this study.

1.9.4. Chapter 5 Search Conferences

This chapter presents the results of the analysis of the data collected from the six search conferences organised. The conferences were organised to further confirm the extent of the problem of access of SVI to science from all stakeholders. The conferences also serve as a forum to seek collaboration with the stakeholders and jointly suggest a way forward. The search conferences represent the observation and consultation stage of the AR, while analysis of the findings of the conferences represents the reflection stage which determines the next stage of the AR cycle.

1.9.5. Chapter 6 Analyses and discussion of the findings in study school 1

This chapter presents the results of the findings in study school 1. It also shows the analysis and discussions of the findings. It is divided into three parts: findings and discussions of data from classroom and laboratory observations are presented in the first part, followed with a broad presentation of findings from e-mail interviews and focus group discussions in Part Two. Presentation of what was observed is cross-referenced with the opinions of the stakeholders from the teachers' email interviews, and focus group discussions with students (sighted and SVI). Then Part Three presents triangulation of the data obtained from the three sources of data-gathering adopted for the study (observations, interviews and focus group discussions). This is achieved with several de-contextualisations of the findings into meaningful chunks. The third part also includes the implications of the findings for study school 1, for the individual SVI, teachers, school, government of the states and also for me as the lead researcher.

1.9.6. Chapter 7 Analyses and discussion of the findings in study school 2

This chapter is similar to Chapter 6, but it is presented for study school 2. The findings from classroom observations are analysed and presented and are cross-referenced with data from the teachers' email interviews and focus group discussions with students. The context of the school determined which students participated. Unlike in study school 1, the STEM Kit was introduced to JSS 1 because the SVI in the school were not attending mathematics lessons, and the TLQ, temperature probe and pH sensor were used during basic science lessons for JSS 3 students.

1.9.7. Chapter 8 Discussions, Conclusions, and Recommendations

This chapter presents the general overview of the study, starting with the aims and research questions over the period of the study, from the exploratory study to intervention in the two study schools. This is followed by broad discussions of the findings of the study, summarising findings from the two study schools and emphasising the effects of the difference in the contexts of the two study schools on the findings. The implications of the findings on the SVI in the two study schools, the SVI in other schools, the Management of the study schools, the teacher training institutions, the Nigerian government and other stakeholders are also discussed. The chapter also presents an appraisal of the approaches adopted for this study. The conclusions of the study are also included in this chapter, and finally, the recommendations for further research represent reflections which are expected to continue the AR cycle.

A list of the references and appendices is arranged after Chapter 8.

CHAPTER 2. LITERATURE REVIEW

2.1. Chapter overview

In this chapter, I present the brief context of the study and reviews of relevant literature on concepts that are important to understanding this thesis and to clearly identify the gap to be filled with the findings of this study. The purpose of this was to use the literature in order to convert my original broad aim (to develop strategies of involving SVI in Sciences in Nigeria) into more focussed research questions. The following areas were considered important: definition of visual impairment, analysis of the Nigerian educational system and comparison of it with the systems in developed countries (the UK and the USA, where existing resources are produced and tested) in terms of the policy, curriculum and pedagogy. I have also appraised science teaching in Nigerian schools and special education provision; particularly provisions for SVI in Nigeria. The discussions also include the importance of science and mathematics to the SVI, the challenges to learning science for the SVI in Nigerian schools, the current solutions available for including SVI in sciences, inspirations from scientists and mathematicians who are blind or visually impaired, and the role of the expanded core curriculum with regard to the SVI. The theory of learning science, especially in relation to SVI accessing the science curriculum, research on the use of assistive technology for the SVI and finally, an appraisal of available resources are also presented. The chapter concludes by presenting indicative research questions.

2.2. Context of the study

The focus of this research is on the exploration and development of teaching resources to better include SVI in science and mathematics in Nigeria. This study broadly focuses on how SVI could have access to science and mathematics like their sighted counterparts. Who are SVI? What is available in the literature about the possibility of SVI having comparable access to science and mathematics? Are there tested resources and teaching models? What relationship exists between the education systems of countries where existing resources are produced or tested and the Nigerian educational system? What educational provisions are available for the SEN and SVI in Nigeria? Which theory of learning is relevant to enable SVI to participate actively in science and mathematics? Do SVI have prior knowledge, experience or independence that could support their access to science and mathematics? What is the relevance of expanded core curriculum (ECC) to the learning and independence of SVI? These and other key ideas are expounded in this literature.

Removing barriers to the learning experienced by children is an international issue that has been supported by various policies (Sheehy, 2013), such as the Education for all Handicapped Pupils Act (Public Law, 94-142) and Individuals with Disabilities Education Act (Public Law, 99-457) in the USA (Lindsay, 2007); and in Nigeria, the Nigeria National Policy on Education and the Nigeria Child's Rights Act of 2003, among others. The manifestation of the policies and acts in Nigeria is seen differently by researchers. According to Lang and Upah (2008), "there is little appreciation that disability is fundamentally an issue inexorably linked to and rooted in human rights" (p.6). Oluigbo (1990) however said that "disabled

Nigerians now compete favourably with their non-disabled peers in every field" (p.1). Oluigbo based his claim on visually impaired and hearing impaired professionals who are bankers, lecturers in our tertiary institutions and practicing lawyers. There has been marked improvement but there is still much to be done.

2.3. Definition of Visual Impairment

Visual impairment is sometimes discussed in terms of educational, medical or legal parameters. The legal definition is used when it is necessary to prescribe or determine the support by a Government or an authority to children or adults with visual impairment, while the educational definition is used to determine appropriate educational provisions and school placement for school children with impaired vision. The most widely adopted is the medical definition which uses the measurement of visual acuity to classify the levels of visual impairment.

The term 'visual impairment' is used to describe the continuum of sight loss. It is a consequence of vision loss caused by a range of problems that affects the sense of sight (eyes) in children and adults (Mason and McCall, 1997). The term is also described by Cox and Dykes (2001), as conditions of the eye or visual system that result in less than normal vision, such as: poor visual acuity, restricted range of peripheral vision, poor contrast sensitivity, or a combination of these. The condition of the eyes may or may not be correctable, and might have been present at birth (congenital) or acquired through trauma, disease, or degenerative conditions of the eyes, brain, or nervous system. A more detailed definition of visual impairment is given by Douglas and McLinden (2005), as a term that describes a wide continuum of loss in visual function such as: visual acuity (ability to resolve detail), accommodation (ability to focus), field of vision (area which can be seen), colour vision and adaptability of light (p.26).

Four levels of visual function were also identified, according to the International Classification of Diseases (2006). They are: normal vision, moderate visual impairment, severe visual impairment, and blindness. The World Health Organisation (2001) grouped moderate and severe visual impairment under the term 'low vision' (Resnikoff et al. 2004). The classification based on assessment of visual acuity is shown in the table below:

Table 2.1: WHO classification of visual impairment

Visual acuity	**WHO classification**
6/6 to 6/18	Normal vision
< 6/18 to ≥ 3/60 (Less than 6/18 but better than or equal to 3/60)	Low vision
< 3/60	Blind

According to Mason (1996), the Snellen test is the most commonly used test to determine visual acuity, although the determination of visual acuity with the Snellen chart is criticised because of its limitation with respect to children who cannot read, recognise or verbalise the letters on the chart. However, variations of the Snellen chart have therefore been devised for younger, preverbal children, or for those with learning difficulties (E chart). This requires the child to indicate the orientation of a particular object or picture instead of figures or the alphabet, and it may also involve matching objects of similar orientation.

For this research, the definition of the World Health Organisation (2001) is apt, which like the medical definition classifies visual impairment based on assessment of visual acuity. Students with visual impairment are therefore those who are blind (visual acuity < 3/60) and those who have low vision (visual acuity < 6/18 to ≥ 3/60). They are unable to see normal print, and the diagrams that dominate the science curriculum. A person with low vision has some reduced sight which interferes with everyday activities like writing. This definition does not include those with refractive errors that can be corrected by wearing eyeglasses or contact lenses (WHO, 2001). The International Classification of Functioning, Disability and Health, (ICF) framework of the WHO was redeveloped recently to reflect a move from being a ‘consequences of disease’ classification (1980 version) to becoming a ‘components of health’ classification’ (WHO 2001, p.4), in which a person’s functioning and disability are conceived as a medico-psycho-social model (Shakespeare, 2006). According to Douglas et al (2012), this modification places much emphasis on inclusiveness and social participation. There is a shift from the use of disability and handicap to the idea of activities, participation, and environmental factors. ICF framework vocabulary will be adopted in all aspects of this study, especially when assessing the expanded core curriculum (ECC) competence of the SVI.

2.4. Education in Nigeria

The Nigeria educational system emanated from the UK and US systems because of the influence of colonial rule (Fabunmi, 2005; Obiakor, 2006). Nigeria gained her independence in 1960 from Britain, and, as identified by Holsinger and Cowell (2000), “many ex-colonial countries kept old colonial curricula for a surprisingly long time indeed; some have been maintained until the present day” (p.18). The determination to drop the inherited foreign policy that is considered to give little consideration to the cultures of Nigerian people (Obiakor and Malthy, 1989) led to the formulation of the National Policy on Education in 1977, after a successful curriculum conference in 1969. The policy recommended a 6-5-4 educational structure to replace the 7-5-4 structure left by the colonial governing body. In addition, the 6-3-3-4 structure was introduced in 1985, which witnessed massive importation of laboratory and workshop equipment (Fabunmi, 2005) for all states of the federation as steps toward implementing the National Policy on Education set goals of “technological transformation of Nigerian society” (FRN 1977, revised in 1981 and 1989). Children spend six years in the primary school, three years in the junior secondary school, three years in the senior secondary school and finally four years in the tertiary institution depending on the desired course (Obiakor, 1998). The enactment of Nigeria Child’s Rights Act in 2003 and the replacement of Universal Primary Education (UPE) with Universal Basic Education (UBE), which was enacted into law in 2004 (Aladeselu, 2010), introduced a new dimension to the Nigerian educational system. Children now undergo nine years of compulsory Basic Education (primary and junior secondary school) before potentially proceeding to the senior secondary and tertiary institution (6-3-3-4 became the 9-3-4 system).

Education is funded in Nigeria by the three tiers of government: federal, state and local government, with the federal government responsible for the largest share (Agunloye et al, 2011). The federal government allocates less than 2% of the consolidated fund to the UBE. Apart from the budget allocated to education, the funding of special education in the primary and junior secondary schools (now called Basic 1-9, equivalent to USA grades 1-9) in the UBE programme is paid directly to the Universal Basic Education Commission (UBEC) by the federal government. The proportion for special education is redirected to the desk officer in charge of special education. The fund is used for the provision of resources to special schools and schools mainstreaming special educational needs children, irrespective of the ownership of schools (Aladeselu, 2010). The visually impaired, the blind, the hearing impaired, the deaf, the orthopedically challenged and the emotionally disturbed are listed as beneficiaries of government provision (Federal Department of Education, 1999).

2.5. Special Education provision in Nigeria

The Nigerian policy provision for special education and its implementation in schools are discussed under this section**.** According to Abilu (2012), special education is a means of raising both the self-esteem of people with disabilities and societal awareness of their potential.

From the onset, Section 8 of the 1977 National Policy on education contained the policy provision on the education of students with special needs Azanor (2014). The following three objectives were listed:

1. To give concrete meaning to the equalising educational opportunities for all children, their physical and emotional disabilities notwithstanding.
2. To provide adequate education for all “handicapped” children and adults in order that they may fully play their roles in the development of the nation.

3. To provide opportunities for exceptionally gifted children to develop at their own pace in the interest of the nation’s economic and technological development (p.36).

In the same edition of the national policy, the government indicates efforts to carry out a census of all handicapped (sic) children and adults, and also accepts the responsibility for making provision for training teachers in special education, including supportive staff required by the schools, colleges, clinics and centres. The policy also provides for the inclusion of elements of special education in the curriculum of all teacher training colleges and all education faculties of universities. In addition, the policy emphasises that integration is the most realistic strategy, since special educational needs (SEN) children are expected to live in the society after schooling. Furthermore, it says that the government will make education of all handicapped children free at all levels up to university, and that special units, well-staffed and equipped, will be provided in specific existing schools under the Universal Primary Education (UPE.) The 2004 edition of the policy included an additional objective: “to design a diversified and appropriate curriculum for all the beneficiaries”. The importance of special training and continuous professional development of the personnel to keep abreast of latest teaching techniques was stressed. The architectural designs of schools will take account of special needs students to emphasise adoption of inclusion strategies in schools. The Nigerian government has also made a series of policy statements, and formulated strategies such as the approved National Strategy for the Education of Persons with Special Needs (FME, 2009), which states clearly that the vision of the Federal

Ministry of Education is to provide access to quality education that will enable every citizen to compete globally, regardless of disability, by the year 2020.

Commenting on the implementation of the policy, Lang and Upah (2008) in their scoping study on disability issues in Nigeria reported that rehabilitation centres have been established in the six administrative regions, in addition to the special schools established by each state and the Federal Capital Territory, Abuja. (Some of the schools have sections for more than one disability.) Furthermore, nine of Nigeria's 36 states have appointed disability advisors to advise the government about disability issues. In 2015, President Muhamadu Buhari appointed a visually impaired veterinary doctor as his senior special assistant on disability matters (the first post in Nigerian history). In addition to the government schools, some missionary schools and private schools exist and are spread across the country, such as the Pacelli School for the Blind and Visually Impaired in Lagos which was established by Catholic missionaries and the Archdiocese of Lagos in 1962, and the Salamat Olaniyan Memorial Model College in Oyo which was established in 1996 and mainstreams learners with different forms of disabilities. (sic).

The special schools take care of the primary school education of the SEN while each state admits special educational needs children to specific secondary schools in inclusive classrooms. Separate resource rooms with separate staff are provided for schools mainstreaming more than one disability group**.** Children of secondary school age who cannot attend the mainstream schools (due to the severity of the impairment) attend vocational training centres. There is no separate school provision for other forms of disabilities. However, inappropriate screening, or the unavailability of screening at all, has led to the wrong placement of many students with special needs.

Another significant effort of the Nigerian government was the establishment of schools. According to Abosi and Ozoji (1985) the first school for blind pupils was established in Kano in 1944 by missionaries; however, the first conventional school for blind pupils was set up by the Sudan United Mission (S.U.M) at Gindiri in Plateau State in 1953. In 1958 other schools were established in every state in Nigeria. The government also established the Federal College of Education (Special) in 1977, and departments of Special Education in the Universities of Ibadan in 1974, Jos in 1977 and later Bayero University, and the Universities of Calabar and Uyo. The College and the special education departments have contributed significantly to the education of students with special educational needs (SEN) (Garuba, 2003; Aromolaran, 2005).

The Nigerian government also budgets a particular percentage of the federal allocation to the Universal Basic Education (UBE) Commission for providing resources for teaching students with special educational needs in Nigeria basic schools (Abilu, 2012).

Research shows a great improvement in the provision of instructional materials in UBE schools (Obiakor, 1998 & Abilu, 2012). An individualized educational plan is not practised as in the USA. There is a limited number of evaluation specialists, and evaluative services are crudely done by special education teachers (Adaka, 2010), so no extensive tests are done to determine the eligibility for categorisation of the disability, hence the majority that are recognised for special education services are those whose disability is obvious (Agunloye et al, 2011).

However, each mainstreamed school has a resource room, and is overseen by the school-level special education coordinators. These are to ensure that ‘systematic planning, organisation, and monitoring are in place to meet the needs of children with special needs in their respective schools’ (Aladeselu, 2010. p.8), although the resource rooms in some schools are almost empty (Abilu, 2012). The type and quantity of resources in each school varies, depending on the status of the school (Private, Federal or State) and on the experience and commitment of the resource person in the school. The desk officer in each state is responsible for preparing and submitting proposals on what should be supplied to schools for each disability. What the desk officer recommend depends on his/her limited knowledge about the disability, as the desk officer is usually a specialist teacher in one area. What provisions are available for educating students with visual impairment?

2.6. Provision for SVI in Nigeria

Visual impairment is one of the disabilities recognised in the national policy on education and the provisions are as discussed earlier. Provisions in schools are not identical; it depends on ownership of the school. Federal schools are financed by the federal government, and the state schools are financed by the state government, while the private schools are financed by the individual owner.

The state where the school is located also determines what resources are available, and the provision within the state also depends on the understanding of the needs of SVI by the person in charge of special education and the head of school (Adelakun, 2006).

The type of school also determines what is available. A special school for blind pupils accommodates primary school SVI, while SVI at the secondary school age attend mainstream school, either one specifically for SVI, or one which includes other forms of disability.

In 1993 and 2003 I conducted two different studies that evaluated the teaching of science to SVI in schools for the blind and mainstream schools in south-western Nigeria. I found that the provisions in these schools were patchy. A few schools had a small quantity of models for teaching science to blind students. I think the reason for the inadequate provision (Omede, 2009) was the inadequate supply of TVI to schools, which are expected to adapt resources for the science teachers. There were also very scanty talking devices in the schools. As at that period, computer use was not common in public schools; where available they were used by the teachers/school management. They were not available to students (both sighted and those with visual impairment). Thus, it can be deduced according to Adeniji and Babalola (2015) that the attitude of the educational planners towards the educational of the blind in Nigeria has adversely affected the provision of learning resources for the blind (p.5), although this assertion was not based on any empirical data. However, Enitan (2009) has said that not all subjects can be accessed, and those accessed by the handicapped students here may not be fully accessed as there is not enough equipment for the purpose.

However, all the states involved in the study, except one, have a special school for blind pupils, and one or two schools mainstream SVI in secondary school. Some special schools also accommodate secondary school SVI. Anjiode (2010) evaluated facilities in some schools (Gindiri Secondary School, and the University of Jos). He reported that there were no talking books or audio descriptive videos, but there were large books. He did not examine the laboratories, so we cannot count on the report on laboratory work. There is a dearth of literature on the provision for SVI in Nigeria. From my personal work experience, there are quite a few schools (such as the Federal College of Education (Sp) Oyo) with JAWS on the computer systems that are available to students, but they are not used for teaching/learning science and mathematics. According to Adebimpe, Imam, Akinlubi, et al., (2014), there are a few braille centres, such as the Nigerwives Braille Centre which was established in 1995 and has since been producing braille textbooks (over 200 titles) which are sold at the cost of printed books. They acknowledged mathematics as problematic for the blind, and have organised workshops for students and staff on the use of the abacus, Taylor's frame, and their designed diagram boards. Similarly, the Anglo-Nigeria Welfare Association for the blind (ANWAB) produces braille textbooks, provides rehabilitation, organises computer training and sells other materials to students, schools and professionals. They have not produced braille textbooks for mathematics and sciences. They have attempted to describe graphics in words, as I know from my personal contract with their office

The resources listed in the policy also include resources for educating the SVI who attend special primary school and mainstream secondary schools. Hostel facilities (which might not be adequate) are provided in the schools by the government for the SVI because of the distance of the schools from students' homes, and also due to the Nigerian environment that is not yet inclusive enough to allow safe independent travel for SVI (Adelakun, 2013b).

2.7. Expanded core curriculum (ECC) for the SVI

Discussion of the ECC, its importance, and strategies of implementing the ECC and its relevance to learning science are presented in this section.

The core curriculum consists of knowledge and skills related to academic subjects expected to be learnt by children up to high/secondary school such as English, Mathematics, Science, History, and Geography. It has been argued that in order for blind and visually impaired students to access the core curriculum equitably like their sighted peers, they must be taught the Expanded Core Curriculum (ECC) (Pugh & Erin, 1999). When taught ECC, SVI will have independent access to all aspects of school life and beyond, because 'the skills maximise independence' (Douglas et al 2011, p.39-41). The ECC for the SVI is not new but was referred to by different terms in the past, e.g. 'additional curriculum' (Koenig and Holbrook, 2000); 'unique needs/curriculum' (Wolffe, et al, 2002); 'special needs/curriculum' (Curry and Hatlen,2007); 'non-academic curriculum', 'dual curriculum' (Alonzo, 1986); 'disability-specific curriculum' (Hall et al, 1986); or 'Expanded Core Curriculum' (Hatlen, 1996), which is more recent and common in the literature.

The Expanded Core Curriculum (ECC) includes important skills that are learnt incidentally by imitation or modelling by the sighted (Lohmeier, 2005), but that have been identified to be a potential problem for the SVI. The ECC includes Compensatory/functional academic skills, Orientation and Mobility, Social Interaction skills, Recreation and Leisure, Independent Living skills, use of Assistive Technology, Career Education, and Sensory Efficiency skills (Hatlen, 1996). Self-Determination is also added as part of the ECC by the American Foundation for the Blind (AFB), and the Texas School for the Blind and Visually

Impaired (Huebner et al., 2004; Sapp and Hatlen, 2010). The idea of the greater needs of the SVI dates to 1829, in the first residential school for blind pupils. In the US, it was emphasised that SVI must be educated based on their individual interests and needs (Sapp and Hatlen, 2010).

Erwin et al (2001: 338)' said: "There is a dearth of knowledge about science (school subjects) and children with visual impairments". However, there are numerous significant relationships between the receipt of instruction in ECC-like content areas and meaningful outcomes. In addition, many areas of the ECC were found to be significantly related to each other as well as to employment or postsecondary training outcomes (Wolffe and Kelly, 2011).

Sapp and Hatlen's (2010) survey of the views of teachers of visually impaired on the importance of the ECC to the lives of their students indicated that most of the TVI expressed the opinions that: "The ECC prepares students for life"; that ECC skills is the "difference between life and successful life"; "The ECC is everything… almost more important than academic achievements"; and that students who received high instruction in ECC have "a richer quality life". All their responses summarised the importance of ECC to the SVI. ECC is the heart of the responsibility of educators of the SVI (AFB). It epitomises their right to be different, as it is an opportunity to compensate for incidental learning that is not possible because of their vision problem.

Implementation of ECC is not given the expected attention, despite the consensus that it is critical for the success of SVI. This is not peculiar to Nigeria. Sapp and Hatlen, (2010) noted that some other countries have not given the right attention to the ECC curriculum for the SVI; teachers still spend more time on the academic curriculum at the expense of the ECC. For instance, in the United Kingdom, the ECC is not taught as a separate curriculum; in the survey work by RNIB in 2006, it was shown that the provision of mobility and independence education to children was patchy and inconsistent within the UK.

All these skills are very important for active participation in science activities or lessons; some ECC skills are addressed in parts of the existing curriculum. However, the SVI need more than is taught in home economics, social studies, economics and civic education, because they cannot learn the skills casually like the sighted. Some aspects need to be taught separately, sequentially and systematically, with more emphasis than in teaching to the sighted (Sapp and Hatlen, 2010), for SVI to participate actively in science lessons: for instance, skills needed to be able to negotiate different apartments in the laboratory or class, to interact actively when working in groups, avoidance of accidents and having confidence and determination to participate in activities. Sometimes some ECC aspects must be acquired in order to be able to take part in the core curriculum (science), while some aspects can be learned, practiced and reinforced through participation in the core curriculum. Many ECC skills can be embedded in the general education curriculum. Most general education curricula include skills that overlap with ECC (Sapp and Hatlen, 2010); assistive technology skill is a good example.

Furthermore, findings from Lohmeier et al, (2009), agreed with the earlier findings that the TVI do not have enough time to teach all aspects of the ECC. Wolffe et al, (2002) found from direct observation of the daily routine of the TVI that most time is spent on compensatory skills, and limited time is spent on the other areas of the

ECC, which are taught in an unplanned and unstructured manner. On this note, Sapp and Hatlen (2010) said “If students who are visually impaired are to be successful, the status quo must change” (p. 343).

In addition, Sapp and Hatlen, (2010) said that it can be challenging to incorporate ECC into daily activities of the SVI, but it is feasible. They suggested taking an assessment of the student’s needs, and critically examining a typical school day to indicate periods the SVI can be used, to practice the skills. Sapp and Hatlen (2010) also suggested summer programme, short-term placements, and after-school programmes as examples of other methods of providing instruction in the ECC.

Access to Basic Science (a core curriculum subject) by the SVI could be considered within the dual view of access as identified by Douglas et al, (2011). “Access to learning: when the student is provided with access to appropriate information in order to learn about a particular curriculum area”. According to McLinden and Douglas, (2013) this might build a dependency on the child’s educators. Learning to access is when the child is provided with the means to access information independently (McLinden and Douglas, 2013 p. 253). It has been argued that both accesses are important, but the need depends on individual students. The argument tends to favour learning to access, because of its longer-term benefits; however, the relevance to science education of each aspect of the ECC is discussed in the following sections.

Compensatory/functional academic skills: These are skills needed by the SVI to access all areas of the core curriculum, such as communication skills and speaking and listening skills. It also includes, but is not limited to, study and organizational skills, concept development, and spatial understanding (Sapp and Hatlen, 2010). Spatial understanding is required of where items /apparatus/ reagents are stored and the organizational skill to navigate all items in the work area. Braille or other communication devices are necessary to write out the activities or notes, as well as for efficient communication with peers and the teacher/ TVI, which depends on the level of vision loss of the students or perhaps the presence of additional disabilities.

Orientation and Mobility: Students should be able to learn about themselves in relation to other things around them (Wolffe, 1999). They must be able to move to locate equipment, return same, and locate sinks and other important points in the classroom /laboratory. These actions should be carried out as independently as possible for SVI to enjoy and participate actively in the laboratory.

Social interaction skills: Science activities are sometimes done in groups; therefore, ability to take turns, cooperate with peers and contribute to discussions on the group work is very necessary for active learning to take place. These are learnt casually by the sighted, but the SVI must receive instructions on these skills to be able to actively enjoy science lessons /activities.

Independent Living Skills: These include personal hygiene, money management, home management and time monitoring. For instance, pouring liquids into cups from a bottle, lighting a heater /Bunsen burner safely and other daily routine skills are important foundation for similar activities to be performed in the science laboratory or in activities.

Recreation and leisure skills: These are also very important for active performance in science activities. Some of the actions or steps performed during recreation serve as foundation for some topics in science; Newton's law and pendulum experiment in mechanics have some form of connection to aspects of some games. Participation in recreation could instill confidence in SVI to try activities in science. Some difficult topics can be adequately taught through games as pedagogy (Adelakun, 1998 and Adelakun et al, 2007)

Career education: This is also a very important foundation skill required by all students, especially at the junior secondary level. Students are expected to select a career to focus on after this level. Therefore, a good foundation in career skills would serve as a guide to what subjects are important for a future direction. This needs to be taught specifically to the SVI because the sighted could see or watch casually information on the different job opportunities available on billboards or other advertising media outside, and can frequently ask for explanations on issues such as what job people do, in contrast to the limitations experienced by the SVI. According to the West Virginia ECC curriculum guide, Career Education will provide the visually impaired of all ages with the opportunity to learn first-hand the work done by the bank teller, the gardener, the social worker, artists, scientists, and engineers (Sapp and Hatlen, 2010).

Use of Assistive Technology (AT): Generally, technology is a tool to unlock and expand the horizons of students (American Foundation for the Blind). Assistive technology specifically enables SVI to perform tasks which might not be possible for them to do independently. It can be a great equalizer, enabling children with special needs, (in this case the SVI) to take part in the core curriculum subjects like their sighted classmates. Instruction in AT should be a continuous process in education that is consistent with the advancements in the technological world. Wolffe (1999) suggests that students' fields of interest should be linked with their instructional goals when developing technology skills**.** As contained in IDEA, (2004), Assistive Technology is:

> *"Any item, piece of equipment or product system, whether acquired commercially off the shelf, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of children with disabilities. It does not include medical devices surgically implanted or the replacement of such devices" (p. 11).*

In Nigeria, various assistive technology devices are already available for the SVI, such as braille devices (e.g. Perkins Brailler, Braille Embosser), closed circuit televisions, magnifiers, voice output devices (talking thermometer, watches, weighing balances), adapted computer system software etc. However, these products are not available in the same quantity in schools mainstreaming SVI in Nigeria. This is because the facilities in each school depend on funding and the recommendation of the desk officer in each state SUBEB and the Federal ministry of education (for the Unity schools) (Adelakun, 2006).

It is very important that the SVI be proficient in using both low or high tech technology provided in the laboratory or for classroom activities. In addition, the SVI need to give feedback to the teacher in print and keep a braille copy for personal use. This is only possible with the use of technology. To communicate with the sighted community, typewriters, computers and braille note takers are valuable tools.

Sensory efficiency skills: These skills are closely linked with each other; sensory efficiency skills have to do particularly with the SVI's ability to use devices (AT) that help those with low vision to maximize the use of remaining vision. Learning how to integrate all remaining senses (auditory, tactile and olfactory) to counter/compensate for the impact of any missing or impaired sense is a very important skill needed to actively and independently participate in science activities. For instance, using the sound made when pouring liquids to estimate the level of liquids in a container, or understanding the tactile version of diagrams will be easy for the SVI if the sensory skills are acquired. This is crucial to active and independent performance of the SVI in science laboratories.

Self-Determination: This is closely linked with career education. ECC emphasizes the importance of believing in oneself. It also encourages the SVI to understand his/her ability and the limitations brought about by the condition of the loss of vision. SVI need to develop skills that will make them control their lives, to reach goals they set themselves so they can take an active part in the world around them (AFB) and not aim for the goals set by others who do not understand their ability.

2.7.1. Implementation of the ECC

There is a dilemma concerning whose responsibility it is to teach the ECC. Blankenship (2007 & 2008) and Wolffe et al., (2002) posit that the ECC should be taught by the TVI and/or the certified orientation and mobility specialists (COMS). But in a survey that examined parents and professionals' awareness of the ECC, findings showed that the ECC areas are being integrated into instruction. Thus, Lohmeier (2001 & 2003) suggests that ECC could be successfully integrated into the core curriculum. However, not all aspects and contents of ECC can be taught adequately when integrated into the core curriculum, because of time constraints, and particularly since some ECC components demand specialist attention. Infusion of the expanded core curriculum in the existing core curriculum is seen to be risky, as it might not provide the urgency and emphasis appropriate for the ECC (Koenig and Holbrook, 2000:198). Any additional skills that a pupil needs to acquire should mainly be taught by the teacher of visual impairment, because the SVI does not have the same visual experiences. Therefore, they need to be taught by the TVI who understands their style of learning.

In Nigeria, the ECC provided for the SVI is not designed as a government recognised curriculum. Each primary school and secondary school mainstreaming SVI only design an additional curriculum which includes orientation and mobility, daily living skills, typewriting skills and or computer skills. These are taught in the resource room that is managed by the TVI. Computer/ICT is taken as a core subject in the schools but the SVI need to be specifically taught Computer/ICT because it provides learning to access knowledge, whereby the student is able to read or surf the web for information on his/her studies. Ability to use AT devices (like the LabQuest) might make it possible for students to take readings (access knowledge) during science activities.

The ECC is critical to the independence and success of SVI. It articulates a form of Vygotskian toolkit for the blind students representing the zone of proximal development (ZPD) (Hatlen, 2003).

Therefore, part of this study is to determine whether competency of SVI in the ECC skills might affect their performance and independence in science and mathematics.

2.8. Comparison of the Nigerian education system with those of England and USA

TLQ and the probes/sensors are developed and currently tested in the US, the relevance and context of testing them in Nigeria necessitates comparing the Nigerian education system with that of developed countries**.** It should be noted that the education policy, curriculum, pedagogy of teaching in schools, quality and quantity of teachers constitute the reasons for the comparison presented in this section.

Nigerian educational policy emanated from the UK and USA policy because of colonisation and in response to international pronouncements, agreements, and declarations. The grades 1-9 in the USA (Mai, 2005) and Basic 1-9 in Nigeria have similar age range specifications. The levels of the Nigerian educational system (primary and junior secondary, senior secondary and tertiary levels) are in some senses similar to those of the American educational system (elementary, middle or junior high school, senior high school and then tertiary levels) (Okafor and Anaduaka, 2013). Similarly, the kindergarten in England (year 1) through 5th grade (year 6) is like the primary school of the US and Nigeria, while year 6 to 8th grade is like the middle school or junior high school, year 10 and 11 represent the senior high school and years 12 and 13 is the England 6th form college, the step before finally spending 3 years for a Bachelor's degree in the University. The British system was adopted in Nigeria until the early 1980s when students often attended 6th form college for 2 years before spending 3 years in the University. It is not clear what aspects of British system were dropped and what aspects of the American system were adopted, and there is a need for a comprehensive evaluation of the Nigerian educational system to be able to categorically decipher its current state.

2.8.1. Curriculum

Schmidt *et al* (2001) stated that curriculum has a major effect on students' achievement and it also plays a crucial role in providing opportunities for students' learning. Curriculum change is a common phenomenon in countries of the world; a new national curriculum was introduced in September 2014 in parts of the UK and the USA. However, according to Holsinger and Cowell (2000), curricular emphasis in the UK and the US is about a broader and more universal experience for students. The emphasis is on "the practicality and social usefulness of schooling and on learning by doing" (p. 15). There will be an increase in the development of scientific inquiry skills to compete with other countries of the world (US Department of Education, 2013) and, unlike before the eighteenth century when the focus was on developing logical thinking, the Industrial Revolution of the eighteenth and nineteenth centuries put emphasis on science and technology, which led to the introduction of new practical and vocational subjects in the national curriculum (Duggan and Gott, 2002). The Nigerian educational curriculum also witnessed a series of changes over time (Ivowi et al 1992). Before independence, the schools were established by the Christian missionaries and the colonial governing body and the curriculum was structured to enhance literacy and knowledge suitable for evangelism (Eriba and Achor, 2010). Realisation of the need for useful knowledge and rapid development led to the national curriculum conference of 1969 which resulted in the formulation of the first National Policy on Education in 1977 which in turn witnessed revisions in 1981, 1998, 2004 and 2008. The repeated revision of the National Policy on Education is a progressive reflection of Nigeria's determination to offer quality education for its citizens and most significantly reflect the needs and aspirations of Nigerian people. Nigeria is currently operating a curriculum that is science, social science, arts and vocational studies based (Aladeselu, 2010). The curriculum also changes as Nigeria changed the educational systems from 6-5-4 to 6-3-3-4 and now 9-3-4. The new curriculum is expected to be realigned to meet the Millennium Development Goals (MDGs), Education for All (EFA) Acts and the National Economic Enhancement Development Strategies (NEEDS) (Uwaifo and. Uddin 2009). However, there are similarities in the content area of the subjects offered in schools. The changes are more of pedagogical techniques of achieving meaningful learning of the contents and are more of conceptual and procedural understanding. There is also more emphasis on particular content at different key levels. Holsinger and Cowell (2000) noted as a positive development that teaching contents in many countries are homogenized at the lower secondary education level.

2.8.2. Pedagogy

The Sputnik satellite of the Soviet Union in 1957 accelerated the reorientation of the secondary curriculum around academic structure. Inquiry or discovery learning with inductive as opposed to deductive teaching methodologies were adopted

(Holsinger and Cowell, 2000). The teaching techniques in US science classrooms/laboratories are mostly student-centred; guided inquiry, cooperative learning and other techniques that encourage active participation of students are common (Mai, 2005). Teachers use a variety of styles in Nigerian schools; however, chalk-talk technique is the most common in Nigerian public schools *(*Osakinle, et al**,** 2010**;** Aduwa-Ogiegbaen and Iyamu, 2005; Hodges, 2001), which promotes rote learning (Watkins and Akande, 1994). Ogunmade (2000) also confirmed in his study of the status and quality of science teaching and learning in Lagos State, Nigeria, that the chalk-talk method, which encourages rote learning was mostly used by teachers.

In addition, Eriba and Achor (2010), in the study of the effect of school type and teacher gender on classroom interaction patterns in integrated science classes recommend that less of the lecture method should be used in secondary classes. However, teaching in schools used by Supalo in the USA while evaluating the TLQ – e.g. Badger High School (a pseudonym) – includes pairing of SVI (Nate [pseudonym]) with sighted classmates (up to four sometimes). According to Nate he acted as a recorder during science activities "Even though he wanted to participate in every aspect of experiments with his group partners, Nate had often been given the task of data recorder because he could not see well enough to make detailed observations" (Supalo, 2010 p 151). This is quite similar to the experience of SVI in Nigerian schools (Adelakun, 2013)

2.8.3. Teacher quality and quantity

The quality and availability of teachers also constitute a significant effect on teaching and learning. Aladeselu, (2010) observed that teachers of English, Science, Mathematics and teachers of students with visually impaired (TVI) are never sufficiently supplied to schools. The reasons could be attributed to high manpower demand, the comprehensive and diversified nature of the curriculum, huge financial demand for a teacher’s salary, high attrition rate, brain drain syndrome, and students not opting for the teaching profession (UNESCO Abuja Newsletter 2010). Students 'lack of interest in the teaching profession is noticeable in the very low number of students applying to Nigerian Colleges of Education (NCE). Consequently, most Colleges of Education recruit students through the Pre-NCE programme designed for students who do not possess the required grades in their Senior Secondary Certificate Examination (SSCE). Furthermore, a poor recruitment and distribution process is also identified as a problem affecting the quality of teaching in schools, because a less qualified candidate who is familiar with the politicians may be chosen in preference to a well-qualified candidate. Similarly, distribution of teachers to schools is also lopsided, to the detriment of schools with disadvantaged students, due to political influence (Eriba and Achor, 2010). Politicians manipulate posting of teachers instead of fair posting to where individuals are mostly needed.

2.9. Science and mathematics teaching in Nigeria schools

Science teaching and learning is given prominent recognition by the Nigerian government in recognition of its influence on the technological development of the nation and the possible role it plays in the life of every citizen. Basic Science, or Integrated Science as it was called before the introduction of UBE, is taught in schools by teachers who have studied relevant science subject combination (e.g. Physics/ Chemistry, Biology/ Agricultural Science, Chemistry/Physics or integrated science double major) from a College of Education or Bachelor of Science in Education from a University.

However, science teaching in Nigerian secondary schools suffers from a range of problems (Obiakor, 1992; Adelakun, 1994; Adelakun et al, 2007). Studies show that students perform below expectations in science subjects both at the junior and the senior secondary schools (Eriba and Achor, 2010). The poor performance is attributed to large class size in most schools and ineffective style of delivery of the subject matter (Salau, 1996; Adelakun, et al, 2007; Salami and Nweke, 2012), deficiencies in the delivery of the curriculum, poor infrastructural facilities (Okafor and Anaduaka, 2013), inadequate resources, lack of teaching skills and competence by science teachers (Braimoh, and Okedeyi, 2001; Omorogbe and Ewansiha, 2013), poor classroom organisation, and poorly coordinated students' activities (Akale and Nwankwonta, 1996). Furthermore, recruitment of teachers is done by the Federal and State Ministries and individual private institutions depending on the ownership of schools. The Teaching Service Commission (TESCOM) is an appendage of the State Ministry and has worked with the State Universal Basic Education Board (SUBEB) from the inception of Basic Education, while the Federal Civil Service Commission recruit teachers for the Federal institutions (Ogunmade, 2000) through a series of shortlisting, examinations and interviews.

However, diagnosing and finding solutions to problems of science teaching is often focused on the senior secondary schools, when the learners according to Eriba and Achor (2010), will have already formed their opinions about science. The junior secondary school is the level where learners are taught science (in its general/integrated form) as a foretaste of the real science to be offered in the senior secondary school. The quality of the foundation laid in the junior secondary science always determines to a large extent the disposition of learners towards learning science. Audu and Achor (2003) conclude that interaction in the classroom entails an active encounter of the teacher and the learners, and for both partners to achieve their purposes, the method of teaching in use ought to create opportunities for the required interaction to take place. Particularly this is so for acquisition of knowledge to take place.

Constructivists see “human knowledge as a process of personal cognitive construction, or invention, undertaken by the individual who is trying, for whatever purpose, to make sense of her social or natural environment" (Taylor, 1993 p.268). In other words, knowledge is not a transfer of truth to the learner but it is being constructed by the individual learner, hence the learner is not seen as a passive receiver but as an active constructor of knowledge (Bybee, 1997). Furthermore, “What the learners already know is of key importance in this construction process” (Duit, 1996 p.41). This is very much emphasised by three key constructivist scholars, Piaget, Ausubel, and Vygotsky. On the basis of this, the sighted build and accumulate prior knowledge from casual observation of the environment, thus the SVI need to be taught the expanded core curriculum (ECC) for them to have the opportunity of the basis upon which the new knowledge will be constructed.

There is a need to explore these provisions for SVI in Nigeria in order to be able to advance the claim of the relevance of TLQ and STEM Kit in the Nigerian school setting.

2.10. Challenges to learning science by the SVI in Nigeria

As discussed earlier, whereas the sighted students face a lot of challenges when learning science, the challenges posed to the visually impaired students are arguably much greater. The teachers teaching science generally have no knowledge of how to teach SVI because they are subject specialists. The resource person managing affairs in the school resource room has some knowledge of the education of SVI (possessing the Nigeria certificate in education (NCE) in SVI education) but may not be an expert in science (Ajuwon, 2008; Oke, 2006). Thus, there is a limit to the support the resource person can provide to enhance learning science in the inclusive classrooms. Sometimes only one person is appointed to serve all the SVI in different classes in a school. From the experience of Federal Government College (FGC) Ijanikin, new graduate TVI teachers are employed and paid by the Parents/ Teachers Association to support the resource person in providing support to the SVI. Government need to post specialist teachers of SVI who are also science teachers to schools mainstreaming SVI or make provision of resources that can be understood by the subject teachers and SVI.

Furthermore, many research studies (Ajuwon, 2008; Obiakor,1992, 2006, 2011) have been carried out investigating the problems and prospects of special education in Nigeria, but there is little literature on the education of the SVI, or specifically on science teaching in an inclusive classroom with SVI. However, though from the literature it is clear that the SVI learn in the same classroom as sighted students, not much is done to allow them to actively participate in science lessons (Adelakun, 2014). It is established that science is a process of exploring the universe and involves much use of sight (Kumar et al 2001). With the high priority given to learning science in schools, and the role of science in the development of the nation, and especially the role of science and technology in enhancing the achievement of individual potential and independent living, all round efforts should be harnessed to improve the access of SVI to science. One such effort is the teaching of the ECC to the SVI, so that they enter the class with prior knowledge in order to learn science like their sighted peers. Importantly, this study is interested in the exploration and development of teaching resources that could better include SVI in science and mathematics.

Moreover, according to Nzoku (2003) interest is aroused when trying to satisfy a need. Interest is closely associated with motivation; both are action oriented thus "there is an assumed link between what the science teacher does in class and how the learners are motivated to learn" Eriba and Achor (2010 p.49). For this to be achieved in Nigerian science classrooms, researchers conclude from observations over the years that effective delivery of science lessons is a skill that can be acquired by the teacher, to ensure that learning takes place (Achor and Orji, 2009; Udoh, 2008). It is important to note that science is not only a body of knowledge; it is also a way of knowing. "Emerging research evidence suggests that students' grasp of scientific explanations of the natural world and their ability to engage successfully in scientific investigations are advanced when they understand how scientific knowledge is constructed" (Rudolph, 2005 p.36). This implies that “students learn science by actively engaging in the practices of science, including conducting investigations and sharing ideas with peers”. It is the belief of researchers that students come to class with a lot of resources upon which scientific knowledge can be built or linked. Denying students the opportunity to link their learning to their previous knowledge will result in a limited sense of science. How is the expanded core curriculum (ECC) useful to the SVI?

Another major challenge is the model of pedagogy in use by the teachers, whether it is learner centred or teacher centred. Despite conflicting claims for both methods, learner-centred pedagogy has been globally positioned as better than the teacher-centred approach. Schweisfurth (2013) traced the history of LCE to the twentieth century, particularly John Dewey (1916) and Brazilian Paulo Freire (1972) on the link between pedagogy, democratic skills, learners’ disposition and the notion of conscientisation. Mention is also made of the constructivists Vygotsky, (1978) and Brunner, (1966) who are pioneers of ideas that knowledge is constructed by both learners and the teacher. Teachers are considered as facilitators rather than dishers-out of facts. And using the definition by Schweisfurth (2013, p.20), LCE “gives learners, and demands from them, a relatively high level of active control over the contents and processes of learning. What is learnt, and how, are therefore shaped by learners’ needs, capacities and interests”. However, in developing countries stories of difficulties of adjustment are more than success stories (Schweisfurth, 2011).

One of the barriers identified by Schweisfurth (2013), is that the system may not be supported in terms of teacher education and inspection. The policy may support LCE but there is still a tight adherence to tight assessment, material resource shortage, class size and motivation. Teachers are often made to teach in a language (English) in which they are not quite fluent.

This has been shown to make them more cautious in classroom dialogue, and they tend to ask closed questions, and use drills as strategies for ensuring that the discussion does not slip beyond their comprehension or comfort zone (Brock-Utne and Holmarsdottier, 2004 on Tanzania and South Africa). Schweisfurth (2013) suggest a continuum that is context-specific, and more inclusive rather than seeing LCE as a single absolute having only one international configuration. Alexander (2008).

2.11. Why is science important for students with visual impairment?

Through many decades, science has always been considered inaccessible to SVI. This was noted in many early studies (French, 1924; Coville, 1932; Burke, 1932 and Hamilton, 1934). Many early academics believed that chemistry, for example, was beyond the reach of SVI because ‘‘in chemistry so few of the phenomena are perceptible to the blind. This traditional and old-fashioned perception is no longer true with the advancement of technology and innovations” (Beck-Winchatz and Riccobono, 2008). Recent innovations such as the resources adapted/developed by Independence Science, and many similar assistive devices, have shown that SVI can have access to higher levels of science education because these multisensory devices enable phenomena such as those in chemistry to be perceptible to the blind (Supalo, 2010).

Although science was traditionally considered inaccessible (Supalo, 2005; Wild and Paul, 2012), its relevance to SVI has not gone without notice. Historically a number of people have advocated the teaching of general science to students with visual impairment (Coville, 1932). They believed that the knowledge of science helps in the development of adults knowledgeable about the scientific matters important in everyday life. Gibson (1932) advocated the teaching of science to blind children for practical reasons, such as “the ability to take care of their own health, sanitation and home maintenance needs; the elimination of misconceptions; the development and honing of critical thinking abilities; the ability to more knowledgeable participation in their communities’’ (p.773).

It was not until the middle of the twentieth century that research into the field of teaching and learning science for SVI gained support and interest from government and charitable organisations in developed countries. Many schools, research bodies, and science and engineering faculties had worked extensively on resources and strategies to improve independence for students with visual impairment in the science laboratory. Examples of such are the Royal National Institute for the Blind (RNIB) in the UK; Macrolab at the New Jersey Institute of Technology; Perkins School for the Blind; Independence Laboratory Access for the Blind (ILAB); Independence Science; and DeLucchi and co-workers in the California School for the Blind. It is believed that provision of appropriate tools and training for teachers of the visually impaired may encourage more students to pursue science-related disciplines (Scadden, 2005). However, the practice of excluding students with visual impairment from practical activities (Hill, 1994; Hill and Jurmang, 1996), or pairing them with sighted partners (Supalo, 2007) encourages a passive approach to learning. This does not conform with the values described in the Education Acts (1990); Individuals with Disabilities Education Act (IDEA, 1997, 2004); No Child Left Behind Act 2002 (UNESCO, 1994; Wright, 2005; Turnbull et al, 2004).

2.12. Resources for teaching Science and Mathematics to VI

I embarked on a literature search for techniques of involving SVI in Sciences and I came across many talking devices. I decided to pick the Talking LabQuest. The LabQuest is a product of VERNIER, designed and used for data collection for sighted individuals. The Independence Science team headed by Professor Cary Supalo added the Sci-Voice software, which according to the team gives SVI equal opportunity in any STEM experiment requiring data collection.

There are quite several efforts made to include SVI in STEM subjects/disciplines. Some involve adaptations to the usual resources used by the sighted (Ricker. and Rodgers 1981); some involve designs of tactile resources; and some involve software as assistive technology resources. Supalo et al, (2007) listed some of them below:

- ❖ 3.5 digit multimeter which was capable of speech output and could measure time, temperature and pH (Salt et al, 1980; Lunney and Morrison, 1981; Morrison and Lunney, 1984)
- ❖ Science Activities for Visually Impaired (SAVI) curriculum, detailing low-tech inexpensive laboratory adaptation for blind and visually impaired students

- Talking calculator from Sharp and Opticon (small camera able to read digital displays on balances) (Cetera, 1983)
- A talking spectrophotometer was introduced by Hinchliffe and Skawinski from the New Jersey Institute of Technology in 1983
- A speech interface that could accommodate the use of more probes. It is called Universal Laboratory Training Research Aid (or ULTRA) (Lunney and Morrison, 1984)
- Speech-capable note taking device, Braille 'N' Speak (Wohlers, 1994)
- Vernier Software and Technology produces Logger Pro software which provides an interface between probes and users. They have designed more than 70 sensors working with the interface.
- Improvement of the Logger Pro software ended up in the LabQuest and with collaboration with Independence Science Talking LabQuest was designed.

Some talking equipment is rather too specific, for example talking thermometers, water jugs, weighing balances etc. Finally, research evaluating such resources is rare. However, there are quite a few research evaluations of the Talking LabQuest done in the developed countries. These influenced my choice to evaluate Talking LabQuest in Nigeria.

2.13. Cambourne Learning Theory

This section presents the Cambourne Learning Theory that underpins my view of science education in this study. It has been emphasised that inclusion is the most suitable form of educating SEN learners, however the quality of inclusion is also important for visually impaired people to learn like their sighted peers.

I have argued that learners with visual impairment have problems accessing visual cues and casual observations/incidental learning. That information acquired is inconsistent and fragmented (Lewis and Allman, 2014). The Cambourne model focuses on promoting incidental learning out of the several theories of learning.

Cambourne maintains that learning takes place when the learner is interested, and immersed in the activity/task. This means they will learn when fully engaged in the material/task to be learned. He has listed some conditions to describe engagement: a high expectation placed upon the learner, opportunities to improve and practice, and provision of constructive feedbacks from trusted others (Lewis and Allman, 2014). He also describes immersion, demonstration and engagement with tasks as conditions for learning. When learners are immersed in activities, and also demonstrate what is learnt, there is opportunity to encounter evidence of what is to be learnt, and exposure to actions in the environment. However, for SVI, the teachers, or anyone in a position to teach, need to provide suitable experiences to substitute for experiential/incidental learning. That is to replace the visual immersion, and should ensure that they are meaningfully involved in the learning activities, and this will result in being engaged with learning (Lewis and Allman, 2014).

Cambourne (1988) emphasises that learning takes place when students are engaged in activities to be learned, when they perceive themselves as potential “do-ers” rather than “done-to-ers”. This is very important for learners with SVI because it infringes on their independence. Harrell (1992) and Ferrell (2011) also emphasised that the SVI should not be accustomed to people doing things for them.

Cambourne (1988) listed high expectations, responsibility, approximation, employment and response as additional conditions of learning which increase engagement in learning activities.

Communication of high expectations from the learner will be achieved when they have been given opportunity to make choices and try things out. It is referred to as self-directed learning and critical thinking skills by Cambourne. Approximation means allowing learners to be free to make mistakes, and with a view to employment, they need to use and practice their emerging skills within a meaningful context (Cambourne 1988). That means applying new knowledge and skills to real life situations (Cambourne 1995). Specifically, it is important for learners with visual impairment to learn by doing, using concrete objects, and being exposed to unifying experiences (Lowenfield, 1973). This will provide the students with Cambourne conditions for learning.

Another condition of learning is ‘response’ which means learners must receive relevant feedback on their efforts. This, according to Cambourne (1988), should be non-threatening and must be constructive. The learners with visual impairment cannot easily compare their work with their peers like the sighted would do. The conditions are summarised in figure below:

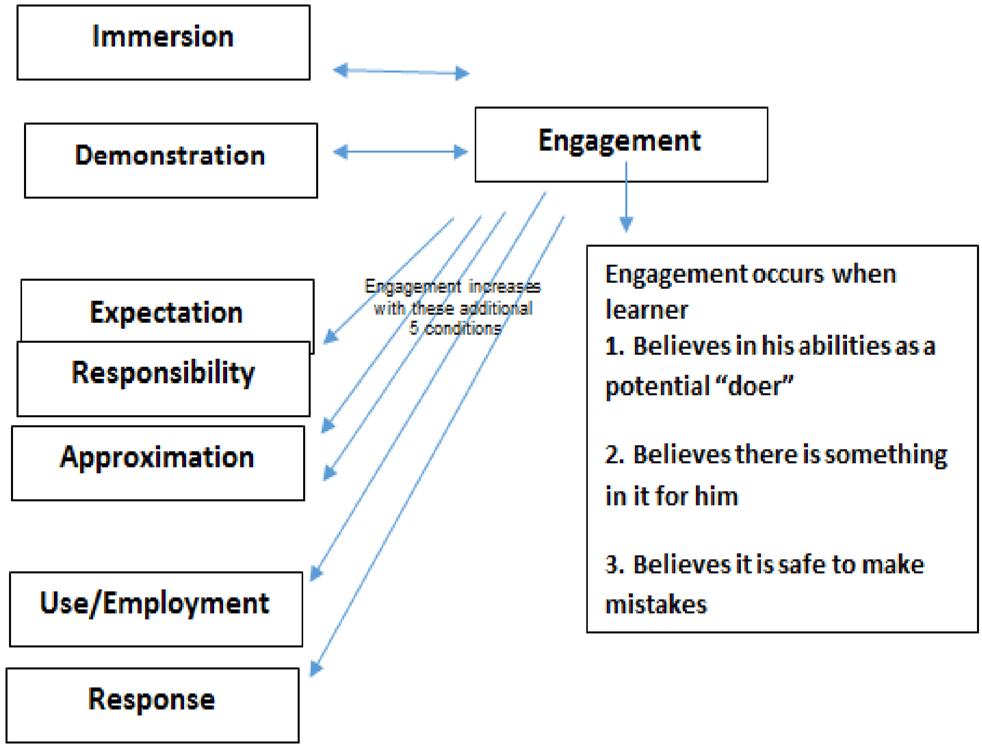


Figure 2.1: Cambourne conditions of learning (adapted from The Whole Story, 1998 p33).

In close association with Cambourne learning theory is Lowenfield's principle of learning. He describes three special techniques for use when teaching learners with visual impairment to overcome challenges brought about by blindness (Lowenfield 1973). They are: providing concrete experiences; offering opportunities to learn by doing; and ensuring exposure to unifying experiences. They are still found relevant today and are considered the foundation of successful instructional strategies for SVI (Lewis and Allman, 2014). These are further discussed below:

Concrete experiences: Observation is an indispensable process in learning. Simply reading through or listening to explanations from the teacher are unlikely to produce the same level of understanding for the SVI as what the sighted learn, and therefore the learners with visual impairment face challenges of learning without clear accurate visual input (Lewis and Allman, 2014). Providing concrete experiences will enable them to overcome these challenges. Considering this in conjunction with the Cambourne theory of learning, a learner will have to be immersed in the learning, and convinced with demonstrations, before adequate concrete experiences can be acquired.

Learning by doing: sighted learners understand better when they explore the task before them. How much more is this true for someone with visual impairment! SVI need to touch, engage, and explore by being involved in activities. Lewis and Allman (2014) have said “It may be said that if a child’s hands aren’t involved, learning may not be happening” (p.12). This is also stressed by Cambourne theory: a teacher that allows learners with VI to learn by doing would have high expectations for the learner, and in the process of learning by doing, learners will be responsible for steps taken, would use skills earlier learnt and would make mistakes and learn from such. There should also be frequent responses during the process of ‘doing’.

Unifying Experiences: According to Lewis and Allman, (2014), learners with visual impairment are often taught activities in isolation and are being denied the big picture or overall scope of activities. This is not good enough, as emphasised by Cambourne (1998), a learner with VI should be able to relate the activity to future, able to connect the task to real life situation.

2.14. Implication of the theory for this study

Cambourne theory and Lowenfield principles have many implications for this study. The SVI in South-Western Nigeria have not enjoyed full inclusion in science and mathematics. As identified in the literature, they have either not been attending mathematics classes in some schools, or attending but only listening to the teacher’s explanations. They also have had only partial access to science, since they have been exempted from any calculations and drawings in science lessons. They have not been registered for the final SSCE examination in mathematics.

With appropriate teaching approaches and teaching resources (such as the STEM Kit and the TLQ which will be described in detail later), the Cambourne conditions of learning could be fulfilled, and VI learners would be immersed in the activities. Starting from the arrangement of the tiles on the metallic board, teachers have the opportunity to demonstrate to the learners, since the learner reads the braille and the teacher reads print simultaneously. The learners will benefit from prior skills (ECC skills) and will use these skills in solving problems in current tasks. Responsibility is guaranteed, as learners make mistakes and also receive immediate and frequent feedback. All these are possible because there is a high expectation for the learner, and with career counselling and the teacher’s explanation during demonstration, learners will be informed of the usefulness and relevance of the knowledge for their future use. They will be ”do-ers” and not “done-to-ers”.

Similarly, as regards Lowenfield’s principles, the resources STEM Kit and TLQ offer the child concrete experiences, because with the sense of touch, tactile means will be involved. Apart from that, the resources offer the learners with VI the opportunity to learn by doing. They also present unifying experiences to the learners, linking the topics/tasks to future of individuals or community, such that the learner will see the need to put in efforts that will bring out success. According to Miner et al., (2001) “Just being there is not enough. Students must be in an environment that permits full access to the educational experience available to their able-bodied classmates. The twenty-first century goal is not just ‘inclusion’ but ‘full participation’.” (p. 5). All citizens in a modern technological society need basic knowledge of chemistry and the rest of science, to make informed decisions and to participate in local and national debates. Scientifically literate citizens are better equipped to make decisions.

Instructors should be aware, for instance, that many people with vision impairments function independently, except for sight-dependent tasks, and should not assume that a student with their vision impaired is helpless no matter how severe this may be (Miner et al., 2001).

2.15. Indicative research questions for the whole thesis

The research originated with my concern about the inadequacy of science and mathematics education for SVI in Nigeria. As outlined in the Introduction chapter and at the beginning of this chapter, I had a broad aim to develop strategies of involving SVI in Sciences in Nigeria. This chapter has identified literature from a variety of contexts (mainly outside Nigeria) to help structure my investigation and identify more detailed and focussed research questions. Even so, the research questions for this study are open ended, one question leading to the development of the next. This emergent style of inquiry has influenced the choice of action research design (discussed in Chapter 4), which considers participants as co-researchers, and it involves reflections at different stages in the spiral progressive structure. The rationale for choice of the design is presented in Chapter 4 in which I link the research questions presented here to the broad aims (see the opening section) and the literature covered in this chapter.

The literature presented in this chapter identified some theoretical and practical ideas to address my aim (to develop strategies of involving SVI in Sciences in Nigeria). However, limited work has been carried out in the Nigerian context or has assessed how relevant the identified literature is in the Nigerian context. Therefore, the research questions of interest are:

RQ1 How do teachers teach Basic Science in a mainstream class with SVI?

- What approaches are used during theory lessons?
- What approaches are used during practical lessons?
- What resources do teachers use in the lessons to facilitate the teaching of science?

RQ2a What are the main difficulties SVI face in a regular science class?

RQ2b What strategies do students use to overcome these difficulties?

RQ3 How can the problem of access to Science by the SVI in South-Western Nigeria be solved?

- How is the problem of access to science and mathematics by the SVI viewed by the various stakeholders involved in the education of the SVI in South-Western Nigeria?
- What ways can improvements be made in collaboration with stakeholders?

RQ4 What is the impact of Talking LabQuest and self-developed Special STEM Kit on the participation of SVI during Basic Science and Mathematics lessons? To answer this question, I looked at:

- The improvement in the level of independence of the SVI when taught with Talking LabQuest and the special STEM Kit
- The change in ECC competency of the SVI when taught with Talking LabQuest and the special STEM Kit
- All students (including the sighted students) perception regarding the use of Talking LabQuest and the special STEM Kit
- Teachers' evaluations of the use of Talking LabQuest and the special STEM Kit

2.16. Conclusion

In conclusion, science and mathematics need to be given a prominent position in the education of all children, considering the inherent advantages and the contribution to life activities and independence of not only the SVI, but all children and adults. It is also important for teachers to provide the enabling environment proposed by Cambourne for meaningful learning to take place. My observations and literature suggests that there is limited inclusion of SVI in Nigerian schools in relation to science and mathematics such that they are partial members of the school, having passive participation in lessons and other activities. In this research, I want to explore how this can be improved.

CHAPTER 3. EXPLORATORY STUDY

3.1. Chapter overview

Science education seems problematic for students with visual impairment (SVI) in Nigeria. This research comes from a concern about identifying the problem and how the problem can be addressed, to give the SVI opportunity to participate actively in science lessons and activities. This *exploratory* study (a small-scale *pre-investigative* study) was conducted with an attempt to obtain empirically grounded evidence from people concerned directly to corroborate observations from my professional background and findings from the literature. The study was also conducted to carry out initial piloting of the instruments (telephone interviews and postal questionnaire) in answering the research questions.

The instruments and procedure for data collection, data presentation and analysis including the reflections that inform planning for the main study are presented in this chapter.

3.2. Research Aims and Questions for the exploratory study

The study includes (a) a preliminary investigation of the way students with visual impairment learn and participate in Basic Science lessons; (b) finding out the resources used for teaching SVI Basic Science in the junior secondary schools; (c) assessment of the interest of SVI in Science, the barriers they face and how they try to overcome these barriers; (d) examination of the differences in the way sighted and SVI are taught Basic Science in South-Western Nigeria. Answers to these questions will inform the design and instruments for data collection for the main study. Basic Science teachers and students with visual impairment were participants in this study.

The exploratory study focussed on RQ1 and RQ2 (identified in the previous chapter)

RQ1 How do teachers teach Basic Science in a mainstream class with SVI? To answer this question, I looked at:

- What approaches are used during theory lessons?
- What approaches are used during practical lessons?
- What resources do teachers use in the lessons to facilitate teaching of science?

RQ2a What are the main difficulties SVI face in a regular science class?

RQ2b What strategies do students use to overcome these difficulties?

3.3. Research methods

Telephone interviews and postal questionnaires are the instruments used for data collection. The rationale, procedure and limitations are discussed below:

3.3.1. Telephone Interviews

Telephone interviews were used in this study, mainly because they save time and cost in travelling. Since the schools involved in the study are in wide geographical regions, this was decided to be the most pragmatic way of contacting as many teachers and students as possible within a short time. Although electronic mail could have been more suitable, not many people in Nigeria have email accounts and even those who have do not check their e-mails regularly. The frequent electricity supply failures in Nigeria and the poor teacher salaries also limit their use of electronic mail. The telephone interview is therefore preferred as most people have access to a mobile telephone. Possession of mobile phones in countries like Nigeria is not considered a luxury but a necessity, as not many places have access to telephone landlines. Secondly, as part of the culture, people tend to respond more favourably if you contact them personally. Thirdly, the in-phone recording facility allows the interviews to be recorded, and can later be replayed several times to enable the full conversation to be transcribed.

The conduct of the telephone interview

In this study, two types of phone interviews were conducted; one for the teachers and one for the junior secondary school SVI. For this exploratory study three Basic Science teachers (TI, TII, and TIII) and two SVI junior secondary school students (SI and SII) were interviewed. They were contacted through their Principals. An appointment was booked to call at their preferred time.

An interview schedule was drawn up in line with the research questions with prompts to allow the researcher to probe for details and also for respondents to provide data that the researcher might not have conceived initially. The interview schedule for teachers and students are presented in Appendix Ia and Id respectively.

The research has been and reviewed by the University of Birmingham Humanities and Social Sciences Ethical Review Committee (Ethics Reference Number 14-0307).

Each interview was scheduled to last 10 minutes and recorded with the in-phone recording facility of my mobile phone. Before the interview, the respondents' permission to record the interview was sought. They were also informed of their right to withdraw at any point during the research. If they did so any data collected would not be used in the analysis. The importance of the study and its relevance to improving the inclusion of SVI in science was emphasised.

The information sheet and the informed consent form (see Appendix Ib, Ic, Ie, If,) were sent by e-mails to the principal of each school who then made copies available to the participants. The parents or school guardians of SVI were requested to read through the students' informed consent forms, and the acceptance slips were to be returned to each principal before the interview was conducted. The principal reported that some students did not return the acceptance slip, and thus they were taken to have refused to participate in the study. A braille and large print version of the information sheet and the informed consent forms were also made available to the participants with the help of the principals of the schools.

3.3.2. Postal Questionnaire

Two questionnaires, one for teachers and one for students were used for the study.

Teachers' questionnaire

Prior to this study, a list comprising phone numbers and postal addresses of schools where SVI receive inclusive education was compiled. The questionnaire was posted directly to the principals of the schools with a request that the teachers of Basic Science in a mainstream junior secondary school section should complete. A total of forty questionnaires were posted. It was not limited to a particular number in a school; it targeted all available Basic Science teachers teaching SVI in the mainstream schools. At least four calls were made and three text messages were sent to each participating school as reminders.

The teacher's questionnaire consists of a set of questions divided into three sections (see Appendix Ig). Each part has clear information on what the respondent is expected to do. The general information and the informed consent were provided on separate sheets. The first section of the questionnaire contains questions about the background characteristics of the respondents, such as age, qualification, class and subject taught. The second section of the questionnaire comprises five questions about how science is taught to SVI with a scale of *Strongly Disagree, Disagree, Uncertain, Agree,* and *Strongly Agree.* The third section comprises open-ended questions on teachers' perceptions about how the SVI could best be taught science, whether SVI show interest in science, and the likely barriers they face. A postage stamp affixed envelope was included in the questionnaire posted to each school to facilitate the return of the questionnaires after completion.

As a token of appreciation for completion of the questionnaire, teachers were awarded a gift of N200 (£1) each. This money was paid directly into teachers' account.

Students' questionnaire

The student questionnaire (Appendix Ih) was sent to ten SVI via the Principal with instructions for completion. The questionnaire was presented in two forms, a magnified one for the low vision students, and a braille copy for the braille readers.

The questionnaire consists of two parts. The first section contains questions about the background characteristics of the student, such as age, class, name of the school and the student's level of vision (low vision or blind). Ten statements with the same scale like that of the teacher's questionnaire about their interest in science and the way science is taught in their classes were presented in the second part. This also attracted a gift of N100 (£0.50) for each student respondent. The use of monetary reward was to ensure a high response rate and partly to pay for their time.

3.4. Presentation and Analysis of Results

The findings presented here are based on interview responses and returned questionnaires from the teachers and the SVI. These are presented in three sections: the demographic data, responses to the interviews and the open-ended questions in the questionnaire, and lastly the Likert scale section of the questionnaires.

3.4.1. Demographic data

Three Basic Science teachers and two SVI were interviewed; 15 teachers returned a completed questionnaire out of the 40 that were distributed, and thus participation rate was 37.5%. On the other hand, 3 out of 10 students contacted returned the questionnaire, giving a 30% student participation rate as shown in the table below:

Table 3.1: Participation rate in the teacher and student questionnaires

Participants	Total Contacted	Total Returned	Total not returned	Participation Rate%
Students' questionnaire	10	3	7	30
Teachers' questionnaire	40	15	25	37.5

Table 3.2 Summary of the teachers' demographic data (N=15)

SN	Characteristics	Options	N
1	Age	20-30 31-40 41-60	5 5 5
2	School classifications	A B C D E	5 2 3 3 2
3	Class taught	JSS1 JSS2 JSS3	6 5 4
4	Subject taught	Basic Science Others	15 -
5	Teach SVI?	Yes No	13 2
6	How Many SVI in the class?	1-5 More than 5	10 5
7	Years of experience in Mainstream classroom with SVI	0-5years More than 5years	6 8
8	Qualifications	NCE BSc. Ed Others	10 4 1
9	Specialisation	Science/SVI Science Others	1 14 -

Table 3.2 shows the summary of characteristics of the teachers. From the 15 teachers that participated in the study, 5 teachers are in each age category. The teachers are from five different schools with at least 2 from each school and they teach the three levels (JSS 1 to 3). The demographic data of the teacher's

questionnaire also shows that all the participants teach Basic Science; 13 of the teachers have SVI currently in the class they teach. The remaining 2 had taught science in an inclusive classroom with SVI before. It also shows that 5 of the teachers have more than 5 SVI in their classrooms, and 10 have less than five SVI in their classrooms. 8 of the teachers have more than 5 years' teaching experience in a mainstream class, and finally all the teachers possess the required qualifications in the relevant areas of specialization expected by the Nigerian government for teaching at the basic education level. 14 studied a science course relevant to Basic Science. One of the teachers has studied integrated science and is also a qualified teacher of SVI. The next section presents the demographic data of the three students.

Table 3.3 Summary of SVI participants' demographic data (N=3)

SN	Characteristics	Options	N
1	School	A B C	1 1 1
2	Type of school	Special school Mainstream school	- 3
3	Class	JSS 1 JSS 2 JSS 3	- 1 2
4	Number of SVI in class	1-5 More than 5	1 2
5	Age	14-15 16-20	2 1
6	Can read braille?	Yes No	3 -
7	Type of visual impairment	Blind Low vision	2 1
8	Onset of visual impairment	Congenital Non-congenital (adventitious or acquired)	1 2

The demographic data of the SVI questionnaire shows that the three students attend different mainstream schools. 2 are in Junior Secondary Level 2 and 1 is in the Junior Secondary Level 3. The age of the SVI respondent, the level of visual impairment (i.e. blind or low vision) and the onset of visual impairment and whether they were braille readers were not included in the demographic data questions, but the information was inferred from the responses. From Table 3 3, two of the students are 14-15 years old, and one is between 16 to 20 years. The three students were braille readers although one had low vision but also read braille. And finally, only one of the three had blindness from birth (congenital).

3.5. Findings from interviews and open-ended section of the teacher questionnaire

The findings are presented under the six broad themes as follows:

3.5.1. Participation of SVI in Basic Science lessons (both theory and practical)

Findings from the exploratory study suggest that SVI listen and copy their notes after the lessons; they do this either by requesting their friends to dictate to them or by replaying the tape (for those who have one) after the lessons to make personal notes in braille. The following are excerpts from the students' and teachers' interviews and are also summarised in table 3.4 after the excerpts:

> *"I get extra help after class from students that know more than me. I record the lesson in cassette so that I can braille the lesson later in the hostel'' [SI]*

> *''Listen, the teacher writes on the board, I collect note and braille after class" [SII]*

“Teacher sometimes describes for us’’ [SII]

‘‘Teacher writes on the board and explains, because I can’t see the notes, I asked a friend to dictate his notes after class” [SI]

Similar responses were received from the teachers as shown in the excerpts from teacher interviews:

‘‘Because they cannot see, they sit in the class and listen’’; [TII]

“Some of them record the lesson with audio tape and rewrite it in braille after each lesson’’. [TIII]

Table 3.4 Summary of identified approaches to participating in science lessons identified by teachers and SVI

Teachers	Students
1. Evidence of passive participation of SVI was mentioned, just sitting and listening 2. Not clear how the SVI access graphics 3. They talk about note copying and not about equipment 4. Tape recording was emphasised, but those who do not have tapes were not mentioned	1. Copying notes after class shows passive participation 2. Not clear if the friends or teacher help with describing diagrams 3. No mention of equipment 4. Used sighted assistants

3.5.2. What resources are available to teach SVI Basic Science?

Responses to the open-ended questions in the teacher questionnaire and the interviews from both SVI and Basic Science teachers indicated that there are currently no adapted resources available to support the involvement of SVI in classroom science activities.

3.5.3. Interest of SVI in Basic Science

Responses from the students' interviews suggest that SVI showed some interest in science both as a subject and as a career. For example:

> *"You can help people as a medical doctor / nurse" [SI]*
>
> *"You will know the process of making a lot of things you use"'[SII]*

Teachers, on the other hand, could not agree. For example, one said

> *"They cannot do science so they don't show interest. "Sight is important to study science"; [TI]*
>
> *"They are exempted from topics that involve drawings"; [TI]*
>
> *"They perform competitively better than other students in topics without diagrams". [TII]*

Table 3.5: Summary of teachers' and SVI responses on the interest of SVI in science

Teachers' responses	**Students' responses**
1. Have low expectation of what the SVI can do 2. Connect ability to see to interest in science 3. Affirm that the students perform well, better than the sighted in the class	1. Recognise career of people who studied science 2. Connection between knowledge of science and resources around the students is also recognised 3. The responses show realisation of the value of science and interest to know

3.5.4. Barriers faced by the SVI during Basic Science lessons

SVI face a range of barriers during Basic Science lessons. The responses are summarised in Table 3.6 after the excerpts from students' and teachers' responses. The students expressed that:

> *"There are no facilities to teach us science" [SII]*
>
> *"We don't see illustrations" [SI]*
>
> *"There are no tactile diagrams" [SI]*

Similarly, the teachers listed barriers to teaching SVI science in the following excerpts

> *"I am not a special teacher; I don't know how to make diagrams available to blind students" [TII]*
>
> *"They cannot become scientists since they cannot see colours" [TI]*
>
> *"There are no facilities to teach them" [TIII]*
>
> *"They cannot handle glass wares and electrical materials used in practicals" [TI]*

Table 3.6 Summary of barriers faced by SVI during Basic Science lessons mentioned by teachers and the SVI

Barriers mentioned by students	**Barriers mentioned by teachers**
1. No facilities 2. Can't see illustrations and drawing 3. No adapted or tactile charts or materials 4. Because tactile format is not provided 5. Because there is no special teacher 6. Science is abstract	1. They can't handle laboratory materials 2. Cannot become scientists 3. Cannot do science 4. They can't differentiate colours 5. There are no special materials to teach them science

The findings indicate that teachers see the lack of resources as barriers to learning science but also some teachers assume that lack of vision means science is impossible. Students indicate that if adapted materials are provided, their interest in science could be enhanced.

3.5.5. Strategies for overcoming the barriers

The findings suggest that these barriers are not so much overcome as side-stepped or ignored. The teachers mentioned that SVI are exempted from mathematics and any aspect of science that require the use of sight: "*This is good for them; they were marked only on other aspects"*. [TII] One of the teachers mentioned that she once allowed the SVI in her class to explore a fish which is a concrete object. Some teachers consider exemption from topics involving activities as a strategy to overcome the barriers, while one teacher adopted involving them when possible which is a move to being included in practical.

3.5.6. Differences in the way sighted and SVI are taught science

All the teachers and the students expressed that the SVI are taught like the sighted. The difference is that the sighted have access to all aspects of the curriculum, while the SVI are missing part of the curriculum. The adapted resources that could have been used to possibly present all aspects of the curriculum to SVI are most of the time not available. The teachers mentioned advocating for exemption of the SVI from aspects of Basic Science that involve activities requiring the use of sight.

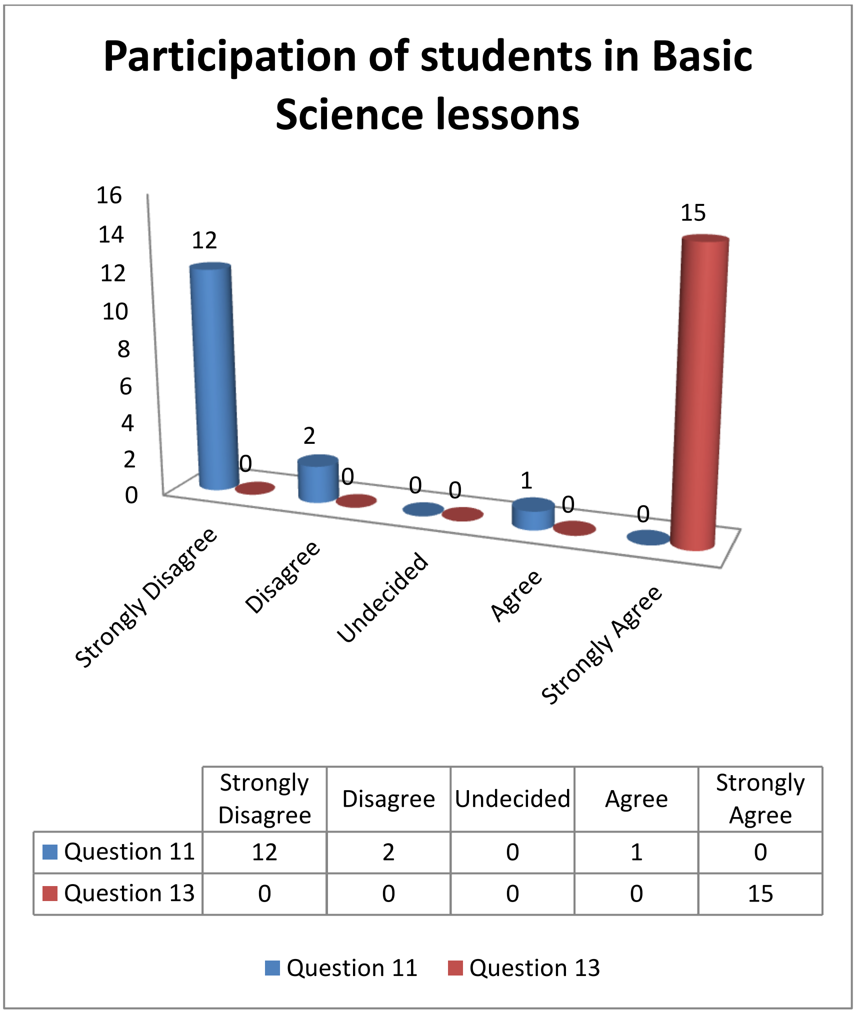
3.6. Findings from student questionnaire and the Likert scale section of the teacher questionnaire

Likert scale part of the teachers' questionnaire:

10. The visually impaired are exempted from science subjects;
11. visually impaired students are involved in science activities
12. There are adapted equipment or special equipment for teaching science in my school
13. Visually impaired students have barriers in learning science
14. Visually impaired students learn science with brailed labeled models

Data from the Likert scale part of the teachers' questionnaire (shown above) and the students' questionnaires (Appendix Ig and Ih) are coded. *Strongly Disagree* is coded 1, *Disagree* 2, *Undecided* 3, *Agree* 4 and *Strongly Agree* as 5. To ease presentation of the results, the numbering of the teacher questionnaire was altered. Items 10-14 replaced 1- 5. The results are presented using descriptive statistics.

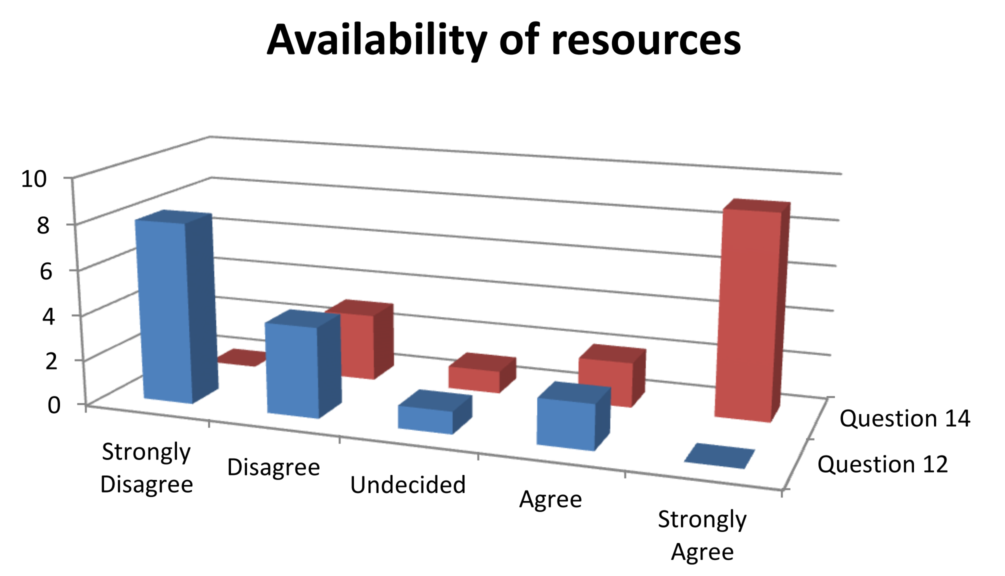
There are important relationships among the responses to the last five questions (10–14) which are graded on the Likert scale in the teacher questionnaire. Questions 11 and 13 of the teacher questionnaire suggests that the SVI do not participate actively in Basic Science lessons and that they also have barriers accessing the Basic Science curriculum. 12 out of 15 respondents strongly disagree with the statement that SVI are involved in science activities, while all the 15 respondents agree strongly that SVI have barriers in learning science as shown in the figure below:



	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Question 11	12	2	0	1	0
Question 13	0	0	0	0	15

Figure 3.1: Participation of students in Basic Science lessons (by teachers N=15)

The responses to questions 12 and 14 of the teacher questionnaire show a somewhat opposite rating about resources and availability of adapted models as shown in Figure 3.2. Eight teachers *strongly disagree* and four *disagree* that there are adapted resources for teaching SVI, while 9 out of 15 *strongly agree* and 2 *agree* that SVI learns science with braile label models.



	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Question 12	8	4	1	2	0
Question 14	0	3	1	2	9

Figure 3.2 Responses to questions related to availability of adapted resources

The responses of the students and the teachers to the questionnaire items are similar. The responses of the SVI questionnaire is summarised in Table 3.7. As mentioned earlier, the responses are coded and presented in Appendix Ii.

Table 3.7: Summary of SVI responses to questionnaire in percentages (N = 3)

S/N	Items	SD	D	U	A	SA
1	I take an active part during Basic Science lessons	3				
2	Our science teacher uses adapted equipment to teach us science	3				
3	I don't like science because I cannot follow what the teacher teaches. No equipment					3
4	I never attend Basic Science lessons		3			
5	I like to do science because our teachers use braille labelled models to teach us science lessons	2	1			
6	I read other things during science class				3	
7	Our resource teacher teaches us science activities after science lessons					3
8	We don't have extra teaching on science				3	
9	I am always happy when we have Basic Science		2		1	
10	Visually impaired students don't do science		1		2	

The responses to items that are similar are grouped and discussed together. For instance, all three students involved in the study rated items 2 and 5 as *strongly disagree.* The items questioned availability and use of adapted resources for teaching science, "*Our science teacher uses adapted equipment to teach us science*", and item 5 "*I like to do science because our teachers use braille labelled models to teach us science lessons*". This implies that resources are inadequate or not used for teaching Basic Science.

There was 100% *disagreement* on items 1, 2 and 4 which relate to SVI participating actively in science lessons like their sighted peers. Similarly, there was 100% *agreement* on items 3 and 5 indicating that they were not taught science after class and there were no adapted resources. Items 7 and 8 have 100% *strong disagreement* and *agreement* respectively. This aspect looks contradictory: they have no extra teaching on science, and yet still agree that the teacher teaches science activities. Perhaps the items may be interpreted differently. Two students, however, *disagree* to item 9 that SVI are happy when they have science lessons. In the same way, 2 students *disagree* to item 10 that SVI don't do science.

3.7. Discussion

Overall, students' responses pointed towards not having adequate access to Basic Science and to the inadequate availability of relevant specialised resources. These could account for the barriers they face in accessing the Basic Science curriculum. The teachers' responses also pointed out that SVI do not have adequate support that could enable them to access Basic Science. Their participation is more as passive learners compared to their sighted classmates. The main difficulties faced by the SVI relate to the erroneous belief of teachers on the inability of the SVI, the unavailability of required specialised resources and the inadequate involvement of the TVI in the education of the SVI. The teaching approaches used by the teachers were not revealed by the two methods of data collection used in the study.

From the results presented, responses of all the student participants are the same for seven out of ten items, items 5, 9 and 10 are divided between *agreement* and *disagreement*, especially 9 and 10. This suggests that at least one had been exposed to science. The difference in responses is likely to be influenced by the different interpretation of the items by each student. Although, as earlier explained, a review of the exploratory study findings reveals some gaps (e.g. the age, level of vision and onset of vision were not included in the questionnaire and clarity of the questions needs improvement to avoid misinterpretation) in the data that suggest that some questions need to be refined and additional questions are needed. There is also a need to revise the method of gathering data.

3.8. Evaluation of the two methods of data collection

These two methods of data collection have their pros and cons. The main criticisms of the interview are that it is time-consuming, produces non-standard responses, brings about invasion of privacy, and data are based on what respondents say rather than what they do (Denscombe, 2003; Punch, 2005). The presence of the interviewer can also affect how interviewees respond to the interview. The gender, age and ethnicity and professional status of the interviewer can influence how interviewees respond (Mason, 2002).

Setting up a phone interview can be problematic, as there may be interruptions during the interview. This was the case in one school where the interview was constantly interrupted by a colleague. Repeated calls had to be made to book a suitable appointment with respondents. Phone interviews with students had also to be planned well in advance, as such interviews were conducted during school hours in the Principal's office. This meant that the Principal had to arrange for a time when he / she was available, and a time when the student could be released from lessons.

Another limitation with telephone interviews is that the researcher may forget very important points if the interview is not recorded; and ethically the respondent should know that the interview is being recorded. Unless immediate backup is done, research data may be lost and it will be difficult, if not impossible, to ask the respondent to do a repeated interview due to loss of data.

In this study, the data collected from the telephone interviews was recorded to avoid loss of data, and backed up on the computer. The data collected from the questionnaire is standardised and the analysis is not complex (Denscombe, 2003; Punch, 2005).

Specifically, with the postal questionnaire, the researcher was able to get information from more participants. However, within a restricted time frame, the length of time taken to post the questionnaire and the time it took for it to be completed and returned made it a time-consuming process.

The financial implications of the postal questionnaires were significant, if one takes into account the amount spent on printing the questionnaire and on postage, also on providing a return postage stamp and envelope, the amount spent on calls to remind the Principal of the schools to hand over the questionnaire to the science teachers and the SVI, calls to remind science teachers to complete and post on time, the time and cost of sending SMS messages as reminders. All these cost too much when compared with the phone interviews. The amount spent on the interviews would not add up to this even if all the respondents were interviewed.

The time it took to complete the questionnaire was also more than the time it took to respond to an interview on the part of the respondent, producing a braille copy of the student’s questionnaire and the magnified copy that uses ten times the size of the paper questionnaire also consumes more time and money. In other words, the telephone interview is much preferred out of the two methods, considering the size of Nigeria as a country and reliability of the postal agency in Nigeria. This constitutes disadvantages for postal questionnaire whereas almost every citizen has a phone even school children, this gives telephone interviews an edge over the postal questionnaire with regard to this research in Nigeria. Though a telephone interview is better when compared with postal questionnaire, its own limitation, of the inability to involve large population, is a big minus. Therefore, there is a need for revision of the methods of gathering data to be used in the main study. This is discussed in the next chapter.

3.9. Reflections

This exploratory study represents a useful and insightful ‘first go’. It has not satisfactorily answered RQ1 and RQ2, but it does offer evidence that the concerns highlighted in the introduction and literature review are well founded – for this small sample there seemed to be clear evidence that the teaching resources and approaches were not accessible, but also teachers often assumed that the teaching of science to SVI was impossible.

The exploratory study has shown how complex the problem of access to science by SVI is, and it has simultaneously served as a pilot study for the methods. It shows that telephone interviews and postal questionnaire alone are not sufficient to answer the research questions. For example, they do not reveal the dependence or otherwise of SVI during science activities. They also cannot demonstrate students' level of participation. Telephone interviews and questionnaire surveys can only provide information which is largely based on participants' self-report. These limitations suggest that other methodological approaches are needed.

One suggestion to overcome the limitations of telephone interviews and questionnaire surveys is the use of classroom observations of Basic Science theory and hands-on-science activities. Similarly, the logistics involved in arranging for students' telephone interviews can be overcome using focus group discussions instead.

The response rate of the postal questionnaire may also be improved by physically distributing the questionnaire and making repeated visits to the schools or better still using mobile phone technology to conduct the survey on one of the social media. This will reduce the effect of the poor postal facilities that may cause delay or loss of the questionnaire, and at the same time allows the researcher to explain the importance of the research to the participants. Students that need extra support in completing the questionnaire can also be assisted by the researcher. For instance, one of the questionnaires was completed with faded ribbon used on a manual typewriter during the exploratory study.

One discovery made during the exploratory study was that most of the teachers used mobile phones to access their e–mails and Facebook. The response rate of the postal questionnaire could be improved if an e-mail/Facebook interview is conducted for the teachers instead of the telephone interview. This does not require a lot changes to the protocol since teachers are always with their phones. As mentioned before, respondents are unable to cross check responses because of the instant response provided on the telephone, but with e-mail/Facebook interview the teacher may check records and delay the response to the question, unlike in a telephone interview.

3.10. Conclusion

This exploratory study to some extent confirmed that there is problem of access to science by the SVI in Nigeria, and that there appears to be a need for a change of the way students with VI are included in science education in Nigeria. This might, therefore, be done through a research process which involves some kind of intervention or ‘action’, and aligns with the other research questions (RQ3, 4, 5 and 6). This was developed in the subsequent chapters.

CHAPTER 4. METHODOLOGY

4.1. Chapter overview

In this chapter, I present the theoretical and philosophical understanding behind the choice of design for this study, the rationale for my choice of an action research (AR) design (which was adopted in the main study) and a short reference to my initial research design consideration. Following this, the description of methods used in gathering and analysing data, the context and outlines of the procedure involved in the study are also presented.

4.2. Theoretical framework

Researchers' view of what knowledge is and understanding of how it could be uncovered affects what is being studied. Lindsay (2010) expressed that ontological and epistemological assumptions of the researcher together make up the paradigm. According to Kuhn (1970) 'paradigm' refers to an overall theoretical research framework. This means that a researcher is prompted by a desire, an intention or push or goals. This affects how the research is conducted. Grix (2004) summed the relationship of the three key terms (ontology, epistemology, and methodology) in the following statements:

> *…that research is best done by setting out clearly the relationship between what a researcher thinks can be researched (her ontological position) linking it to what we can know about it (her epistemological position) and how to go about acquiring it (her methodological approach), (Grix, 2004, p. 68).*

My experience and encounters with SVI in the mainstream secondary schools in Nigeria influenced my motivation to conduct this study. The following expressions reported by SVI from my previous research (Adelakun, 1994; 1998 and 2006) are examples of such encounters:

> *“The teacher gives us tasks a blind person cannot do like drawing diagrams from what is drawn on the chalkboard.”*
>
> *“I looked at many things and felt annoyed! The radio, television, the pressing iron, the phones and the likes, though very useful but how are they made?”*
>
> *“Mummy said she went to the USA. Where is the USA?”*
>
> *“I decided not attending the class again since the day the teacher teaches the types of bones in our body, when I was unable to comprehend the lesson.”*
>
> *“One day, I ran and fell when I heard a noise above my head, people laughed at me they said it was an aeroplane”.*
>
> *“How I wish I could participate in the basic science class!”*

The feeling that the SVI in the schools are unjustly treated and wanting the situation to change represents my “view of knowledge” (ontology) and “what could be uncovered” (epistemology). Furthermore, the change can only be successfully achieved when the stakeholders are involved in a collaborative effort. How could this be done? This represents “how” the knowledge could be uncovered (methodology).

The search for “how” took me through the literature, and to visit schools in England and the AER (Association for Education and Rehabilitation of the Blind and the Visually Impaired) conference in the USA. Finally, I realised through literature that professionals who are blind or have impaired vision exist, and have made (and some are still making) exceptional contributions to knowledge. presented I also realised that various resources were developed by different organisations and service providers to promote access to STEM subjects for SVI, and to encourage them to take up careers in science, and more importantly, live a more independent life by accessing many resources available through the contribution of science.

The whole idea is not fixed within positivism (objective reality) neither is it fully fixed within interpretivism (subjective interpretations), but it involves a combination of the two. It involves emancipation and collaborative effort to change the situation for the better which is the focus of 'critical paradigm' (explored further below). This project, which incorporates exploration and development of teaching resources (the Talking LabQuest and the self-developed special STEM kit), is an attempt to fulfil this desire to bring about change.

I chose this study out of the idea of emancipating others and bringing about a change in the prolonged exclusion of SVI from accessing science and mathematics in schools. As stressed earlier, it is neither a study to predict law-like patterns of behaviour (Taylor and Medina 2013) by experimenting or using standardised tests or statistical analysis. Neither does it involve measuring human behaviour in terms of key variables, or discovering causal relationships among these (Halfpenny, 1982; Hammersley, 2007) which are the focus of the positivist paradigm. I am trying to understand through inter-subjective knowledge construction from the perspectives of the participants, which seems like the focus of the interpretive paradigm. But not only this, my desire is to focus "beyond mere recording observations, it strives to reform for a better world" Asghar, (2013).

> *On some interpretations, interpretivism can lead towards forms of action research where the researcher-researched relationship is turned into something like a partnership, or where the focus is on*

the improvement of professional practice and/or the personal development of an individual (Hammersley, 2007)

I intend to practice “deep democracy”, which according to Kincheloe and McLaren (2000) involves identifying and transforming socially unjust social structures, policies, beliefs, and practices. This is the critical paradigm.

4.3. Critical Paradigm

The critical paradigm shares with the interpretive paradigm through the process of writing as inquiry, but has an additional dimension in that it involves “critical analysis and ideological critique of established policy and practice” (Taylor and Medina, 2013)**.** The critical paradigm focuses on resolving global crises/ emancipation of individuals (Cohen and Manion, 2007):

*It can be done individually or, in collaboration with less empowered others participating in ‘critical action research’ led by the researcher in the role of facilitator. The researcher’s role is one of advocacy, a change agent who argues for and leads the way towards a more equitable, fair and sustainable society (Taylor and Medina, 2013)**.***

There exists war among researchers over which is the best paradigm at one time or the other. Quantitative work dominated educational research up till late 1960’s, followed by qualitative approaches, and later diversified competing approaches evolved (Bogdan & Biklen, 2007; Taylor and Medina, 2013)**.** According to Hammersley, the labels of the approaches are not used in standard ways. When researchers make efforts to distinguish their approach from that of others a new paradigm evolves, like symbolic interactionist ethnography, Marxist ethnography, ‘critical’ research, feminist method, phenomenography, discourse analysis, postmodernism and so on (Hammersely, 2007)**.**

The 20th-century debate became known to be unnecessary because every research has its focus which informs the type of data that is of interest to the researcher. “No research paradigm is superior, each has a specific purpose that provides a distinct means of producing unique knowledge” (Richards 2003:32), because data obtained with a wrong approach will be useless (Taylor and Medina, 2013).

Rather than focusing on philosophical differences, both Hammersley (2012) and Bryman (1988) believe that methods should be chosen according to the research problem faced in the study. Bryman (1988b) argues that:

> *…each design and method should be taken on its merits as a means of facilitating…the understanding of particular research problems, …and an excessive preoccupation with their epistemological underpinnings can only stand in the way of developing such an understanding (p255)*

This illustrates my thoughts about the philosophical ideas and approaches to research; however, I present a brief rationale for my choice of critical paradigm for my study.

My idea of challenging and changing the denial of access to science and mathematics to the SVI shows my philosophical stance. I believe that research cannot be successfully conducted with an approach that distances the researcher from the participants. I share the idea of many researchers over time that research should be problem-oriented, should focus on an evaluation of the programme and the processes involved in solving real life issues and must involve the “final consumer” (Goldberg, 1974; and Schindele, 1985).

My ontological and epistemological position led to the research questions earlier presented and the questions influenced my choice of the action research approach focusing on initiating change which will emancipate SVI from the injustice of non-access to science and mathematics, their inability to pursue education beyond secondary schools (due to no SSCE result in mathematics) and their inability to pursue desired courses in tertiary education (due to inadequate access to science), and reduced independence.

This philosophy guided my selection of an action research design for a problem-oriented study which is “understanding behaviour from the subject’s own frame of reference” (Bogdan and Biklen 1982, p.2), and with a collaborative effort.

4.4. Initial research design

For the main study, I considered using an experimental design (specifically randomised control trial), which according to Torgerson and Torgerson (2003), is considered the gold standard approach for evaluating the effectiveness of interventions. However, I considered the likely impossibility of meeting the required conditions for using a rigorous experimental design on human participants (Cartwright, 2010; Clay, 2010), the difficulty of applying the logic of experimentation on humans, and the complexity of controlling variables in special education research. As a result, I sought an action research (AR) design after reconsidering the purpose of my research, (resolution of the problem, emancipation of the SVI from injustice and my determination towards making a change). It is an approach that requires involving the stakeholders in the study, thereby making implementation and acceptance of the outcome of the study easy.

It is a suitable approach for evaluating instructional methods, materials and programmes (Wolerry and Harris, 1982). It eliminates the distance between researcher and practitioner (Aronson and Sherwood, 1974), involving research subjects in research decisions (Goldberg, 1974) and bringing research and practice together in a creative interplay (Hegarty et al, 1982).

4.5. Rationale for the choice of action research cycle

The research questions proposed for this study can be explored in different ways; however, considering my ontological and epistemological position earlier presented, a broader action research design was adopted. The rationale for choosing AR and the specific model adopted are discussed in this section.

To start with, the views of the SVI listed above (based on my previous research) and the findings of the exploratory study emphasised that there is problem of access to science for the SVI in South-Western Nigeria. There is a need for emancipation of the SVI from unjust treatment. Therefore, the design that would fit perfectly should be suitable for problem-oriented studies, which would allow immersion, and should involve stakeholders in real life situations (Lewis and Allman, 2014).

AR design is most suitable when the focus is on bringing about changes/solutions to specific situations/problems in specific settings, as defined by Waterman et al (2001).

> *Action research is a period of inquiry that describes, interprets and explains social situations while executing a change intervention aimed at improvement and involvement. It is problem-focused, context-specific and future-oriented. Action research is a group activity with an explicit critical value basis and is founded on a*

partnership between action researchers and participants, all of whom are involved in the change process (p iii)

The nature of the research questions and the underlying drive for conducting this study are a major rationale for adopting the AR approach.

Furthermore, AR can be encompassing, involving elements of other designs or strategies, like surveys, case studies, evaluation and even experimental studies (Meyer, 2000). Thus, AR gains from the advantages of the approach, allowing polyangulation of data. Sometimes it involves qualitative and quantitative approaches. AR can be of three types: technical scientific (positivist approach), mutual and collaborative (interpretivist approach) and emancipatory (critical approach). This means that AR can draw upon qualitative or quantitative methods, and can combine both depending on the context.

As claimed by Creswell (2007 p40), “qualitative research is conducted when we want to empower individuals to share their stories, hear their voices, and minimize the power relationships that often exist between a researcher and the participants in a study”.

The major characteristics of AR according to Gummensson, (2000); McDonagh and Coglan, 2001) remain that it is research in action, rather than research about action; participative; concurrent with action; a sequence of events and an approach to problem solving. Action research is therefore considered to be most appropriate for my research because the focus is about problem solving through actions and involving the stakeholders at different levels of participation Krane, Eklund, and McDermott (1991), through a sequence of events. In this case, I am interested in finding a solution to the problem of access to science and mathematics to SVI using various educational resources.

In addition, AR is also a design that could be used to test new initiatives. The developed STEM kit is a new initiative and I am mostly attracted to AR as the best approach for this study considering the participatory/collaborative nature of AR (involving the stakeholders in action) which will make it possible for the end users to contribute to the design. Thus, the ‘research’ and ‘action’ are not separated (Krane, Eklund, and McDermott,1991). This is one of the strengths of AR.

Its unique feature of combining both ‘action’ and ‘research’ also distinguishes AR from other designs involving enquiry such as experimental design. Experimental design is not considered appropriate because of the difficulty in controlling many intervening variables when human participants are involved in research. It is also not considered suitable for my study because the emphasis of experimental design is different from that of AR. Experimental design focuses upon verification or validating the hypothesis by controlling variables, whereas AR focuses upon change and emancipation in collaboration with stakeholders.

This is reflected in the expression that “Research that produces nothing but books will not suffice” Lewin (1948).

> *Perhaps the most important aspect of action research is that the process enhances teachers’ professional development through the fostering of their capability as professional knowledge makers, rather than simply as professional knowledge users (Keeley-Browne, 2014:141)*

I decided to use AR because it is a design suitable for practitioners (Mills, 2011), useful for improving practice and evaluating innovations (Stringer, 2007). I identified the problems of access to science and mathematics by SVI, and wished to solve the problem by developing and testing the efficacy of the developed resources as well as resources already in use in another part of the world. To achieve this, it has to be in collaboration with all stakeholders involved in the education of SVI. The target is to bring improvement to practice/change which is also a crucial aspect of AR.

4.6. Nature of action research (AR)

In my context, AR design is the “systematic procedure done by teachers (or other individuals in an educational setting) to gather information about, and subsequently improve, the ways their particular educational setting operates, their teaching and their students’ learning” (Brydon-Miller et al 2003). Its origin was attributed to a social psychologist Kurt Lewin in the 1930s, although similar effort was credited to some earlier researchers (Grundy,1987); Action research is cyclical in nature and it mainly involves four main stages (Winter, 1996; Kemmis and McTaggart, 1988). “Reflect”, “Plan”, “Act” and “Observe” are the common stages, although some models have more than four stages but the main features are common. The cycle can start from any of the stages. It could begin with Reflection/identification/confirmation of a problem followed by planning of a strategy to bring about a change. The next is action/intervention which leads to reflection/assessment of intervention/action. This could or would lead to re-examining the situation of the problem, based on the previous reflections, and may lead to re-planning/revising the plan, and the cycle continues. It could be represented by the following diagram:

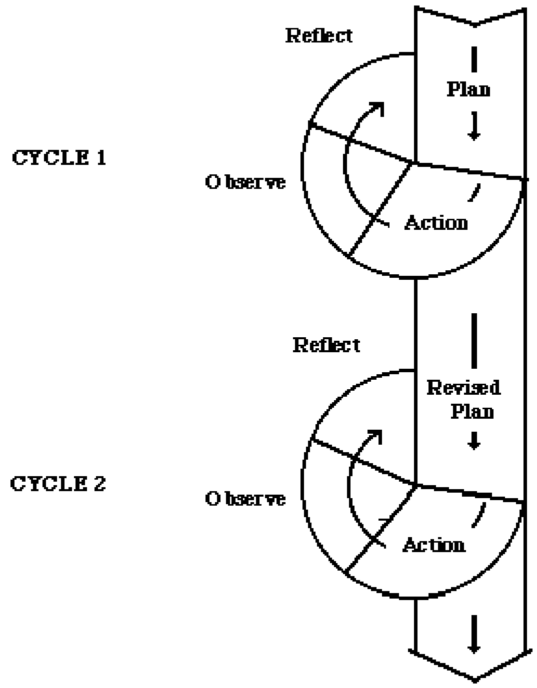


Figure 4.1: Simple action research model (from MacIsaac, 1995)

According to Coughlan and Coghlan (2002) teachers tend to implement practice when they are involved in its development; more so, the reflections of the one cycle (study) inform further cycles in a spiral form. It is open ended. It is also represented as:

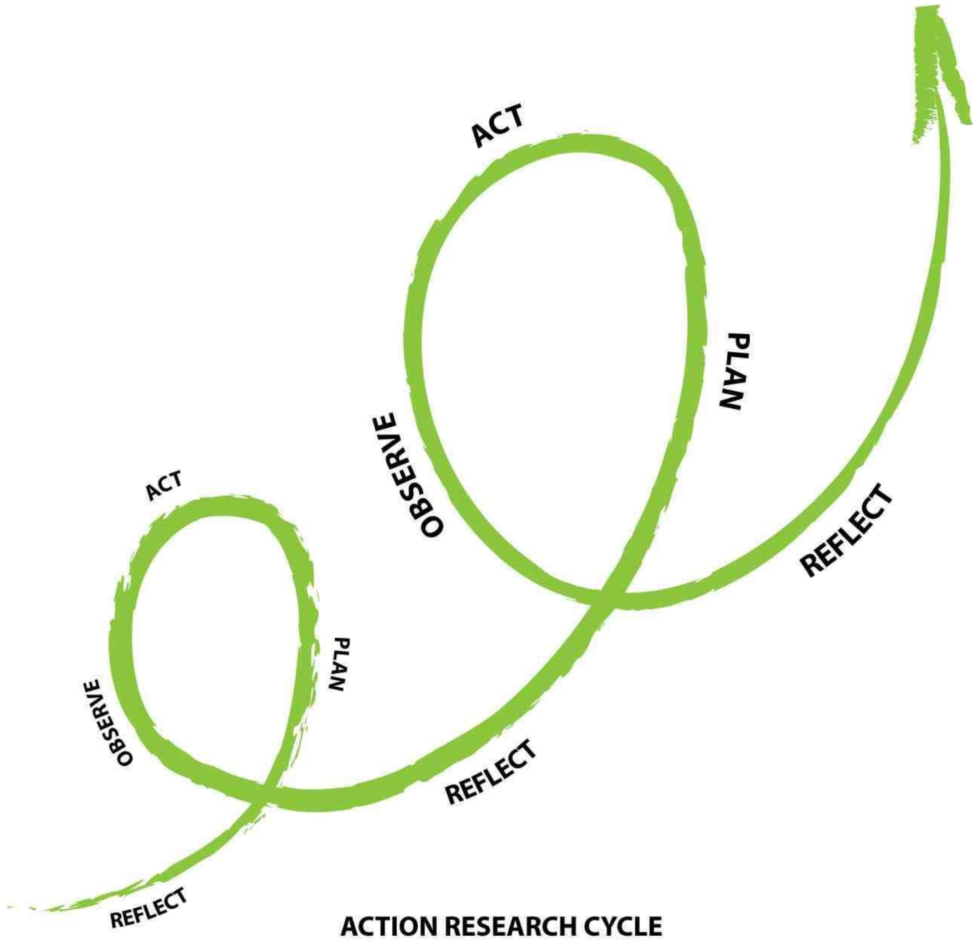


Figure 4.2: Simple representation of an action research cycle (From Centre for Education Innovation)

.

Models of action research vary, depending on the complexity of the study. Stringer (2007) proposed a simple framework involving three stages: “look, think, act” (p.8); whereas Kurt Lewin proposed “fact finding, planning, taking action, evaluating and amending the plan” (Smith, 2007). Just like Piggot-Irvin’s (2006) model, Mertler and Charles (2011), favour four stages: the planning, acting, developing and reflecting stages. Looking through the models, the central themes are problem solving, intervention/action, reflection and the spiral nature.

4.7. Limitations of AR

Like other approaches, AR is not left out of criticism. However, it is important to consider the limitations/criticism in order to consider ways of addressing them or at least make room for them in my analysis.

Prominent among the limitations identified by researchers is the problem of getting the administration of the host organisation (here a school) convinced enough to accommodate any disruptions that may be caused to the establishment. The researcher needs to avoid being arrogant, recognising that these people have so much power, and that their collaboration is important. Therefore, they should be approached carefully (Brydon-Miller et al 2003 p.23).

Another weakness identified is AR's localism, and the difficulty of intervening in large-scale social change efforts because the bulk of action research occurs on a case-by-case basis (Brydon-Miller et al 2003). This limitation can be (addressed by documenting a detailed description of the procedure/steps involved in the study to enable replication in a similar situation which could be larger (Brydon-Miller et al, 2003).

AR is also criticised for lack of objectivity and control of variables, but the relevance, changes or improvement, and validity testing by the stakeholders are much more a focus of AR. Objectivity is not as relevant as the subjective submissions of participants, and as mentioned earlier, research study on human participants can be difficult to control.

Water-Adams (2006) listed lack of time, validity of research, unfamiliarity with research methods and results not generalizable as limitations of AR. Further, he maintains that representation of AR may confuse rather than enlighten (rhetoric of AR may be confusing), or may be in contradiction with the main principles of the process. Some of these claims are baseless because the focus of each approach to research differs, and what constitutes validity in research also differs, as discussed later in this chapter.

As commitment, cannot be measured, the AR process will be criticised on this basis, but the AR researcher must be committed to rigorous examination and critique of his or her practice (Kaur, 2013) which is the underlying principle of AR. Rigour in AR is achieved through procedural checking, such as allowing participants to review the raw data and debriefing the participants as the research proceeds (Stringer, 2007; Kaur, 2013). The transcripts of the focus group discussions were made available to the participants to confirm the accuracy of the data. The email interview submissions were sent by individual teachers and so require no further checking.

Action research is sometimes criticised to be of lower level in quality because it is done by practitioners; a contrasting argument is that the level of quality is “directly related to the usefulness of the research findings for its intended audience” Mertler (2014 p. 27).

Criticism of inevitable researcher bias in data gathering and analysis is countered by the justification and intention for the research. Practice can only be accessed by the practitioner through prolonged engagement and consistent observation (Mills, 2011; Stringer, 2007), and polyangulation of data collection methods could improve the credibility of AR (Mills, 2011). This study employed classroom observations, email interviews and focus group discussions for data collection.

Another limitation of AR identified by Prasad (2001) was that AR may not lead to action, and outcome or change can be achieved by other activities apart from the action. As mentioned earlier, AR is context-specific, directly related to the usefulness of the findings for the intended audience. Since it is cyclical, if the action has failed to produce the expected outcome/change, the cyclical nature of AR allows the practitioner/researcher to re-plan and repeat the cycle.

4.8. Model and overview of AR used in this study

The action research cycle used in this study involves seven broad spiral stages spread over three cycles (Observation, reflection planning, acting, observation, reflection and re-planning) as illustrated in the figure and text below. The detail of what constitutes each stage is presented in the sections which follow.

- Stage 1: Observation (through consultation / search conference)
- Stage 2: Reflection (the analysis)
- Stage 3: Planning (design of the materials, recruitment)
- Stage 4: Action (the intervention)
- Stage 5: Observation (collected data about how it went)
- Stage 6: Reflection (the analysis)
- Stage 7: Re-planning

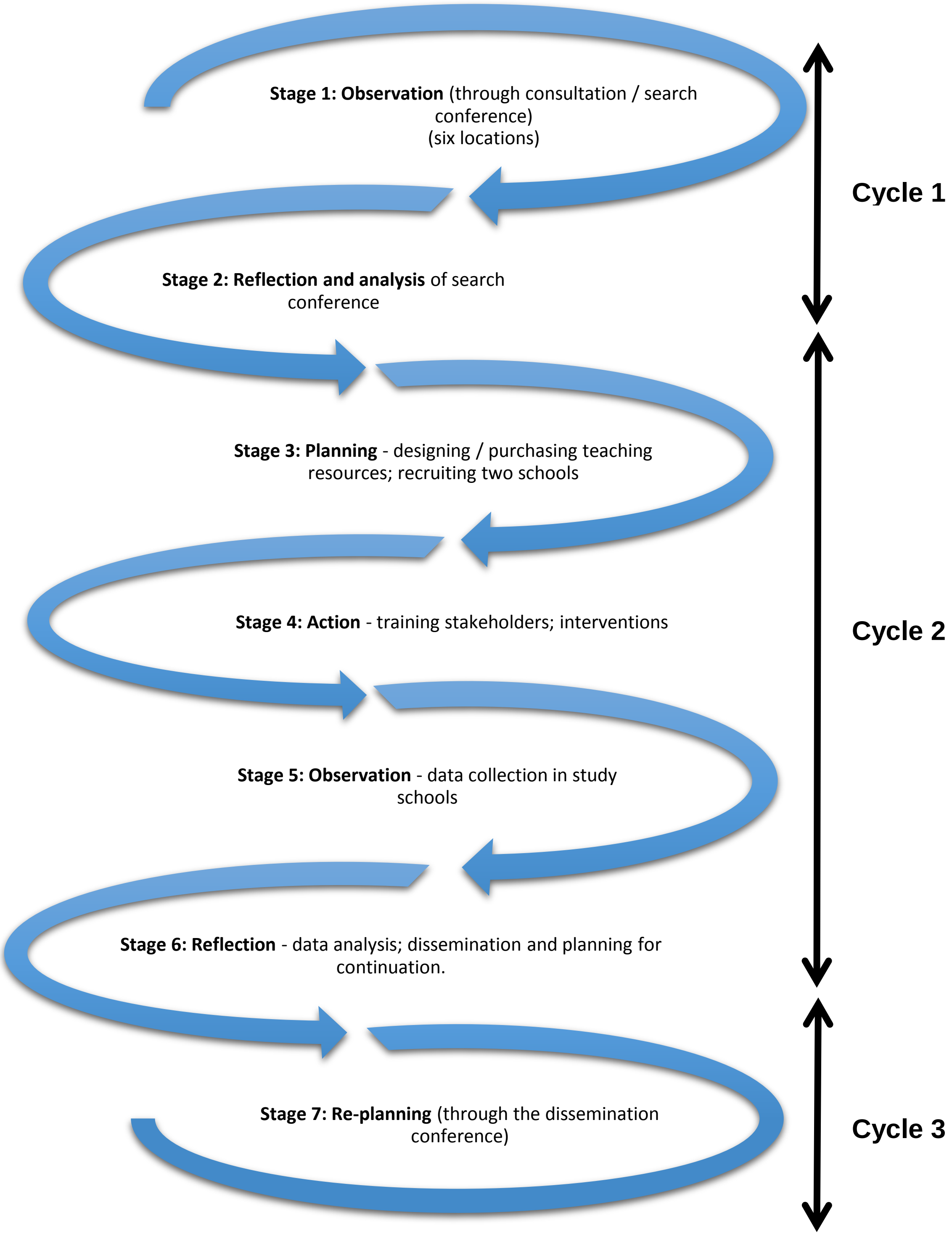


Figure 4.3: Representation of the model used in this research

4.8.1. Stage 1: Observation

As discussed in the preceding sections, it was observed (in my professional observations, in my previous research, and my exploratory study) that the SVI in Nigerian secondary schools have problems accessing science. In order to be able to confirm the extent of the problem, and to seek collaboration with the stakeholders, six ‘search conferences’ were organised. Chapter 5 presents details of the method adopted, and findings. The next sections offer an overview of the methods of data collection and analysis also.

4.8.2. Stage 2: Reflection

The data gathered from the presentations at these conferences was analysed and are presented as findings and recommendations (Chapter 5). Reflection on the result formed a basis for the next stage of the cycle.

4.8.3. Stage 3: Planning

The preceding stages have presented the problem identified, as well as reflections on the result. Finding solutions to the problem requires planning. First comes the planning for the resources to be used for the intervention, for procurement of TLQ and probes from Independence Science, and design and piloting of the STEM Kit by the researcher. Second comes the choice of the study schools. The study schools were purposefully selected/recruited from the available schools mainstreaming the SVI in the South-Western Nigeria. The choice of study schools and classes to be involved was based on the assessment of the students and facilities in all the schools that agreed to participate in the study. Two schools with different contexts that emerged from the findings of search conferences were purposively considered for the intervention. They are those whose SVI reportedly passively attended mathematics and science lessons (or did not attend) as reflected in the conference presentations.

Third, there was also planning for the broad training of participants in the study schools.

And finally, there was the planning for choosing two research assistants to work with the researcher as indicated in other parts of this thesis.

4.8.4. Stage 4: Acting

Action in the study schools involved: familiarisation with the participating schools (SVI, sighted classmates, science and mathematics teachers); conducting initial observations; completing the ECC competency schedule for each SVI; training of participants; implementation during lessons (teaching with the resources by the respective teachers) . In summary, the action stage involved:

- Initial observations of science and mathematics lessons
- ECC competency of the SVI was assessed by the research assistant; competency of the SVI in all the eight aspects of the ECC was assessed with adapted assessment criteria from AFB and Texas School for the Blind (see Appendix IV). The blank spaces on the format allow flexibility so that the TVI recruited as research assistant could include relevant items not originally included.

Training sessions through Skype in each study school were organised for the students, and a separate one for the teachers with Professor Cary Supalo on the effective use of the Talking LabQuest. Separate training for teachers and students about the special STEM Kit for teaching Science and Mathematics was also organised. A convenient time was requested from Cary and the School Principal of each school. The time difference between Nigeria and the USA was considered when scheduling time for the training. Stage 5: Observation

Observing the science and mathematics lessons; e-mail interviews with the participating teachers; and separate focus group discussions with SVI and their sighted classmates. This is summarised below.

- Science and Mathematics lessons were observed.
- E-mail interviews were conducted with the Basic Science and Mathematics teachers.
- Separate focus group discussions were conducted with the sighted in the observed classrooms.
- Separate focus group discussions took place with the SVI in the observed classrooms.

4.8.5. Stage 6: Reflecting

The data gained from classroom observations, e-mail interviews and focus group discussions was analysed. Reflections on the findings represent my thesis recommendations and proposal for the next Cycle(s) /Further studies.

4.8.6. Stage 7 Re-planning

Depending on the result, other search conferences or a single national conference is proposed to give feedback to stakeholders and as part of the dissemination of the research findings. Most importantly, the conference will likely initiate many AR cycles.

4.9. Ethical considerations

Ethical issues in action research are challenging because of the open-ended nature of the design. The researcher needs to update the purpose continuously, and involve participants as often as possible. Anonymity and confidentiality may also be difficult to ensure. However, some steps were taken to address the ethical concerns in this study, as indicated in several places in this thesis.

The approval of the required government and school management was obtained in three stages of the study. Before the exploratory study, search conferences and intervention in study schools, the informed consent and information sheets were given to participants which contained detailed information (See Appendices). Some specific steps are listed below:

- Participants were asked to use pseudonyms during search conferences and focus group discussions.
- They were informed of the voluntary nature of participation in the study.
- They were also given information about their right to withdraw and when it should be.
- The under aged were asked to present the parent informed consent to their parents before participation.

- They were asked to keep our discussions confidential, among other steps taken.

The recommendation of the British Educational Research Association (BERA) and the ethics recommendation in Nigeria were followed appropriately during this research. The consideration is described stage by stage:

During the exploratory study, my supervisor wrote a letter that introduced me and the study to the authority in Nigeria, which enhanced the approval of my study by the authority concerned. Appendices show the information sheets and informed consent distributed to participants. A braille version was made available to VI participants.

I also completed the University of Birmingham Ethics Committee application form and approval was given to conduct the study.

Before the search conference, information sheet, and informed consent was sent to all the stakeholders that took part in the conferences (see Appendix IIa to IIh). Furthermore, separate information sheets and informed consent forms were presented again to the Principal, for the science and mathematics teachers, SVI and sighted students in the respective classes used for intervention in the two study schools (see Appendix III a-g). The students under 18 years old were requested to take the informed consent form to their parents (see appendix IIIc). Those living in the boarding house got the consent of their parents through their individual school guardian before they were involved in the study.

The right of participants to withdraw from participating in the study was included in the information sheet, and the informed consent form, and it was clearly explained to them that the data would be removed if the intention to withdraw was raised a month after data collection (see Appendices) because analysis would have started.

During the data collection procedure, the participants were asked to use pseudonyms to fulfil the confidentiality mentioned in the informed consent form. The teachers and students were given IDs, and pseudonyms were also used for school details (name, location, local government, state etc). The focus group discussion was organised in the chosen place of the participants in their school.

During each stage of data collection, the data collected were stored according to the UK Data Protection Act (1998). The data on the video recorder was uploaded to my PC after each collection, and the file was secured with a strong password. Data recorded on papers were also kept in a bag with a lock, and it was only opened by me. This was transferred to a cabinet in the doctoral researcher's study room, and always kept locked away. The research data will be kept (preserved and accessible) for ten years. The Zip folder will be stored on the student researcher's university computer, protected with a strong password to ensure confidentiality. On my leaving the university, the data will be passed to my supervisor for similar storage.

During analysis of findings, pseudonyms and IDs were maintained and since the participants were co-researchers in the AR study, they were aware of parts of the findings and were informed that the findings would be published but that their identity would not be revealed.

Ethics in AR is critiqued because of the open-ended nature and the type of methods adopted. However, further steps taken are:

1. The participants were informed to keep our discussion during focus groups confidential.
2. The data was retrieved from the research assistants immediately after recording, as confidentiality of findings was part of the informed consent signed by participants.
3. The respondents were also informed of what I intended using the data for.
4. Similarly, they were informed how I intend to preserve and use the data after the study.

4.10. Implementation of the AR Model

4.10.1. Stages 1 and 2: Search Conferences

In this section, the methods and procedure adopted for the search conferences are presented while the findings and analysis are presented in Chapter 5.

Overview

A plan to organise a single search conference was initially proposed, (to bring together all the stakeholders involved in the education of the SVI in the South-Western Nigeria). However, after an initial consultation with some stakeholders, one search conference was organised in each state and a separate one for the unity schools. This is necessitated by the problem of getting the relevant government officers to consider attending a conference organised by a researcher in another state and the logistics of getting the teachers and the students to the venue (permission, cost implication, and who bears the cost).

Recruitment for the search conference

Recruitment was through the existing relationships of the researcher with the schools, teachers, and Ministry officials as a lecturer/teacher trainer in the Federal College of Education (Special) Oyo, Nigeria. The officer in charge of Special Education at the Universal Basic Education Commission (UBEC) office in Abuja also introduced the researcher to the SUBEB offices in the six states in the south-western zone and solicited for cooperation with her on the study.

Following the approval from relevant organ of government (See Appendix II a,b,c,d for the information sheet and consent letters) a separate letter of invitation to participate in the search conference was sent through DHL to the Honourable Minister for Education, the Director of Special Education in the Federal Ministry of Education, The Honourable Commissioners for Education and Directors of Special Education in the State Ministry of Education in the six states in South-Western Nigeria, and the Chairmen of SUBEB and desk officers in charge of Special Education in the six states' offices.

The ministries were implored in a separate letter to invite the TVI, science and mathematics teachers and SVI to a day conference in the ministry's conference hall/SUBEB hall depending on the agreement between the two representatives.

All the letters were sent through DHL express services to ensure delivery of the letters, in order for them to be given due consideration. My contact details (email and phone numbers) and my supervisor's email were provided on the letters for easy feedback and communication. Specific dates for each state were finalised through phone conversations, except one state that was busy with its governorship election and could not finalise the arrangement at that time. A separate conference was organised for the Federal/Unity schools in South-Western Nigeria. Therefore, six search conferences were organised in total.

Attendance

The search conference in each state took place at the agreed venue with the stakeholders in attendance. In all the five states, we had in attendance representatives of the Commissioner for Education; the Director of Special Education; the chairman of SUBEB, and the Director in charge of Special Education (three of them have visual impairment); Basic Science, Basic Technology and Mathematics teachers from schools mainstreaming SVI: and the SVI and the TVIs in the schools. A similar letter was sent to the Minister of Education and the Director of Special Education at the Federal Ministry of Education, Abuja through DHL Unfortunately, no representative of the Ministry attended the search conference organised for the federal schools. Separate letters were sent to the principals of the Federal Unity Schools through DHL twice however; two Principals sent representatives, and the relevant participants (teachers and SVI) but the third Principal claimed that the students and teachers were engaged with school examinations and could not attend.

Below is the summary of the students' and teachers' attendance at the conferences.

Table 4.1: Summary of participants attendance at the conferences

	Teachers	Ministry officials	SUBEB representative	TVI	JSS	SSS
State A	14	2	-		13	12
State B	7	2	1	2	5	4
State C	14	3	1	3	3	
State D	27	2	4	2	10	10
State E	16	2	2	4	12	6
F	7	1	NA	2	4	4

A=Oy B=On C=Og D=La, E= Ek F=Un

Procedure

On each day of the conference the schools mainstreaming SVI under each state reported at the venue promptly, except in State B where the Director wanted monetary gain before inviting the schools after being mandated by the commissioner to facilitate the conference. He later invited them when I paid him money for entertaining the participants.

The researcher gave a brief introduction of what she identified as a problem for SVI in schools and projected a paper that she had presented at the Pixel conference in Italy titled “Inspirations from Scientists and Engineers Who Are Blind and Visually Impaired - Lessons to Initiate New Direction for Science Education of Blind Students in Nigeria” (Appendix VIII). She also showed some clips from a book she published “The directory of visually impaired professionals in the field of STEM” and videos from the website of Independence Science.

The participants were then requested to form plenary session:

- Government officials
- Science teachers
- SVI in Junior secondary schools
- SVI in Senior secondary schools and
- TVI

Each group was asked to deliberate on the problem of access to science to SVI in their own context, specifically,

- they were asked to confirm or otherwise the existence of the problem
- to discuss their experience regarding the problem
- to suggest solutions/ways of solving the problem, if a solution was desired.

To ensure the confidentiality of the participants, they were told to use pseudonyms if they so preferred at the beginning of the conference. A representative of each group came forward and presented deliberations on behalf of each group. All the representatives later produced a communiqué for each of the conferences. The conference was covered by newsmen in two states and it came out in a newspaper (see Appendix IX).

The conference was video recorded and I also kept a reflective journal on the research, of events that might not be captured by the camera or audio recorder. It would also serve as a backup in case the recording was faulty**.** The transcripts were prepared, uploaded to the thesis NVivo project file and was analysed. The findings, analysis, and reflection are presented in Chapter 5. The reflection informed what constitute the planning stage of the AR highlighted earlier

4.10.2. Stage 3: Planning, including designing the resources for intervention

The resources needed for intervention are the TLQ, probes, and the special STEM Kit. Procurement and development are discussed below after some short information about the resources**:**

The Talking LabQuest and probes

The talking LabQuest is a hand-held, durable, and portable device for field activities or classroom experiments. Taking real-time data readings for inclusion and participation in the experiment. According to the producer it uses more than 70 Sensors suitable for use in virtually any science course. It also includes an on-board interactive, talking periodic table with 20 audible descriptors for each element. With Sci-Voice Software, students hear the announced data which is being directly collected onto the hand-held computer and they can then analyse the data on the accessible data table. The Talking LabQuest can be used as a stand-alone device, computer interface, or in the field. When acting as an interface, Logger *Pro* and a screen reader must also be used for accessible data collection (Independence Science)

Figure 4.4: The Talking LabQuest

Special STEM kit

The special STEM kit is designed to fulfil the needs of the SVI in mainstream schools making calculations and studying diagrams/pictures accessible. It is made up of a board and tiles of different sizes which have both braille inscriptions and sighted letters/figures/symbols. The kit represents the exercise book and pen of the sighted students. The subject teacher can then involve SVI in mathematics and science in a similar way as the sighted students. SVI would feel the braille inscriptions while the teacher reads the prints on the same tiles just as they read what the sighted writes in the exercise book as shown below:

Figure 4.5: Sample classwork done with STEM Kit

Getting the Resources

This section presents the procurement and development of resources used for intervention. The section also contains the procedure taken for piloting and validation of the developed resources.

Procurement of the Talking LabQuest and Sensors

The LabQuest was designed by Vernier Software and Technology. Independence Science, the company founded and headed by Cary Supalo, adapted it by adding/installing software to make it voice out readings of all the features of the LabQuest. The TLQ is sold by Independence Science. Therefore, I placed an order for the LabQuest and six sensors (temperature probe, pH sensor, sound level meter, drop counter, light probe and salinity sensor) at their exhibition booth during the AER conference held in San Antonio, Texas, USA and they were delivered to me before I left the USA.

Development and Design of STEM Kit

The notion of how to actively involve SVI in Science and Mathematics has formed the major preoccupation of my mind for the past five years, and I have tried different materials on different topics before attending the AER conference in San Antonio, USA where I was opportunely able to attend presentations and workshops which ignited the design of the STEM Kit.

The development of the STEM Kit followed different stages. It also involved a change of materials. There are three parts in the design, the metallic board, the tiles and the graphing pack. Each of the parts was designed following different stages, and these were piloted during the process of design. Below are the design procedures:

The design of the metallic board: The working surface of the metallic board was made in three sizes, 11 by 11.5 inches, 11 by 14 inches and 11 by 20 inches, in order to be able to identify which sizes suited most, considering the classroom space available to each student.

The metallic board was initially designed to have a magnetic property; magnets from faulty or wasted radio/TV speakers were gathered in large quantity. They were ground to smaller sizes and filled in between two metallic sheets. These were spread to cover all the surfaces, thinking that metal tiles would be attracted to the surface of the board. However, the magnetic attraction was not evenly felt on the surface. Thereafter, I prepared another board with a sheet of metal and 1 inch by 0.5 inch wood was nailed to cover the sharp edges of the metal. Sheets of braille paper were initially used to cover the faces of the metallic sheet, but this swells after a week, and it was finally replaced with white rubber stickers which remained firm after three months.

The design of the tiles: When I was designing a magnetic board with magnets from speakers, Initially, the printed inscription of figures 1-9 and 0 were made on braille paper. This was pasted with a different type of gum on a metal sheet cut into small sizes (0.5 by 0.5 inch). Some dots were wiped out on the braille paper, and the paper became dirty and soaked quickly within a week even during production.

During the period when the board was not magnetic, I checked shops selling arts and crafts materials, and I was able to get smaller rounded strong magnets. Then I embossed braille paper, which was duplicated on thermoforming sheets, with the thermoforming machine in the Department of Visual Impairment Education, Federal College of Education (Special) Oyo. I duplicated many sheets, being optimistic that braille lasts longer on thermoform sheets. The thermoform sheet was not dirty and did not soak easily like the braille paper, but the dots also faded away even quicker when the paper was pasted on the magnets with different types of gum. Finally, different materials were tried on the embosser and PVC sheeting was finally found appropriate. The figures, symbols and all that is required were embossed on the PVC sheet and the dots remained after three months.

Based on this, the exact sighted symbols /meaning of the embossed was typeset on a Microsoft Word document with varied font and sizes. The printed sheet and the embossed PVC sheet were taken to an artist to copy the printed version on the embossed symbols on PVC sheets. This was later cut out and pasted with glue on the round magnet bought from the crafts shop, although the magnet was very strong but it was a better alternative. I visited another arts and crafts shop to find magnetic material with a lower magnetic force that would be more comfortable to use, and I found self-adhesive magnetic material that was less strong than the round magnet. I therefore have had the printed PVC cut out pasted onto the self-adhesive magnetic tape which can be cut into desirable sizes with small scissors.

Piloting of the Special STEM Kit: The STEM kit was validated and piloted in a private mainstream school that is in my environment. I have easy access to the school because I was one of the supervisors appointed by the proprietor of the school before I commenced my PhD. I visited the school during lunch break time and sometimes after school hours. The teachers teaching Science and Mathematics assisted me by using the kit with three different SVI and observed how easy or difficult it was for them, and the suggestions were found valuable at every stage of the design. The students complained a lot when the small strong magnet was used. They also complained of limited workspace with the smallest board size, and so the two bigger sizes were used for the intervention. Many font sizes were also tried until the comments of the teachers were favourable.

4.10.3. Stage 3: Choice of study schools

As earlier mentioned, Action Research involves using elements of other research designs to be able to extensively study the impact of the educational resources which are new innovations. There is a need to study the effectiveness of the innovations in smaller units; therefore, study schools are chosen in order to be able to explore the topic thoroughly.

Among schools that participated in the search conferences, two categories can be obtained in terms of access of SVI to mathematics. The SVI showed passive participation in mathematics lessons in some schools, while they had no participation in mathematics lessons in some other schools. Those with passive participation attend mathematics lessons but only to listen, and have no participation in classwork or home work, while those with no participation leave the classroom when the mathematics teacher enters. The demographics of the two schools are presented later in this chapter.

4.10.4. Stage 4: Procedure for the training of participants

The training followed the same pattern in the two study schools, therefore the procedures are presented together in this section. Training of participants is necessary because the resources are new to the system for both the teachers and the students. It is also important because it is part of the action. SVI, basic science teachers, mathematics teachers and TVI in the study schools were trained to use the Talking LabQuest with temperature probe, pH probe, conductivity probe and light probe by Cary Supalo to avoid experimenter bias. The training also covered the use of the special STEM Kit self-developed by the researcher.

Five-hour training was organised for the teachers and three-hour training for the SVI in each of the study schools. The Independence Science team provided the free webinar training for the participants. The training focused on the use of the Talking LabQuest for the following topics: Acids, bases and salts; Electrolytes; Measurement of volume; and pH determination. The training also includes the use of the Special STEM Kit for solving questions on long division, indices, graphing and the balancing of chemical equations.

A set of Talking LabQuest and the four probes, along with a set of the special STEM Kit was left with each study school for one week after the training, to give the teachers the opportunity to explore the resources independently, and to start using it for teaching. This is to allow resolution of issues that may come up when a new thing is introduced.

During the period of classroom observations, more sets of resources were provided, depending on the number of SVI in each school, and there were extra sets with the researcher in case of faulty equipment in any of the schools during implementation. The probes are limited to four because the topics to be taught during the period of intervention require finding the temperature of substances. These also involve determination of pH of liquid samples, light experiments and finding the conductivities of samples. This study will only establish generalisation on the few items used among the resources, and a larger trial will be needed to generalise the findings in a wider context. This is one of the limitations of this study.

The training was conducted separately in each of the study schools. All the resources needed for conducting the training were available in study school 1. The school internet facility was turned on; the public-address system was connected to amplify Cary's voice during the training. My internet facility and public address system were used in study school 2.

On each training day, I usually started training on TLQ with YouTube videos of Independence Science, which show blind students performing laboratory experiments with the TLQ. I allowed some SVI to try some simple measurements with the TLQ and the probes, such that the limited time with Cary was well utilised. Students and teachers engaged Cary with further questions since they already understood some of the common functions of the TLQ. SVI engaged him in turn, asking him questions about the functionality of the TLQ and questions to confirm his sight condition, when he became blind and the possibility of SVI pursuing science disciplines.

4.10.5. Stage 4: Data collection methods used in the main study ('action' stage)

As mentioned earlier, classroom observations, email interviews, and focus group discussions were adopted to collect data in the main study. It is necessary to explain the features, advantages and disadvantages of these methods. The procedure followed during the intervention is presented in the subsequent section.

Classroom observations

Classroom observation is one of the data collection tools used for this research. This method is chosen because it allows the researcher to gain insight into the research settings (Adler and Adler, 1994; Cohen and Manion, 2007) and body language and nuances will be captured.

For this research, semi-structured observation (selective and focused) was used to address the research questions**.** It was selective in the sense that particular attributes are studied (participation of SVI in both Basic Science and Mathematics, engagement with the resources, the level of dependence on sighted support during the hands-on activities or theory lessons, main difficulties faced by the SVI, and application of the ECC skills acquired during the intervention). This was documented with a provisional checklist or field guides (Appendix IV). Moreover, with this type of observation, there was flexibility in the mode of observation, attributes that are relevant but not included in the checklist would be included as it unfolded during observations.

Limitations of observation method

Like other methods, the following limitations of the observation method are identified: Hancock (2002) points out that when the researcher uses only written description as the method of collecting observational data, the researcher may miss out some events while writing down the last event observed, and may focus on a particular incident, ignoring little events that may be more important. Thus, recording the observed activities is encouraged.

Furthermore, direct involvement of the researcher especially when the lesson is being recorded may have an effect on the data collected. The participants can consciously modify their behaviour if they are aware that they are under observation with audio recorder or video camera, as reported by Angrosino et al. (2000), and the validity of the technique is questionable if the researcher relies only on observed activities, because some important actions may not be adequately captured. Therefore, interviews were used as a follow-up to the observations and the data was cross-analysed.

Focus group interviews

The distinctive feature of a focus group is that the researcher plays the role of a moderator or facilitator during the focus group interview, after generating interaction between interviewees about a topic (David and Sutton 2011). A focus group inspires people to consider how they feel about issues in the light of other people's feelings (Moore, 2000).

The purposes of focus groups in the context of this research are:

1. To find out from the SVI the difference in the level of participation and independence before and after using the resources in the study schools.

2. To find out the perceptions of SVI and the sighted in the study schools about the use of the resources.

3. To find out the main difficulties faced by SVI with the resources, and how the resources can help more.

As suggested by Thomas (2009), I generated discussions about the experience of students with visual impairment during Basic Science and Mathematics lessons before the intervention, and what their experience was during lessons taught with the resources (see next section for detailed procedures). Two focus group discussions were organised in each study school, one with the SVI and one with their sighted classmates.

The reason for using focus group discussions is to allow participants to contribute freely. Another major advantage is the reduction of the researcher's influence on the research. If well organised, apart from reducing the cost of meeting individual participants, they present a setting where participants will probe and argue with one another in a way the researchers could not do. This offers a more detailed understanding of the issue under discussion (Hobson and Townsend, 2010). As encouraged and demonstrated by Radway (1984), I gently encouraged the participants and backgrounded my involvement during the interview. This allowed "the conversation to flow naturally while the participants disagreed among themselves, contradicted one another, and delightedly discovered that they still agreed about many things'' (p. 48). Using this strategy, Kamberelis and Dimitriadis (2012) noted that it "helped to mobilize the collective energy of the group and to generate kinds and amounts of data that are often difficult, if not impossible, to generate through individual interviews and even observations'' (p. 555).

Limitations of focus group discussions

A potential disadvantage is that participants may not contribute equally in the process of trying to be civil to each other. Their personalities and the relationships between members of the group and the context of the focus group can affect the data generated from the discussions (Krueger and Casey, 2009). Specific rules formed at the beginning of the discussion encouraged them to contribute well individually. Their social relationships before the discussions also helped. They were told that there were no right or wrong answers so that they freely expressed themselves.

Finally, another limitation is in the area of the withdrawal of participants. Since it is a discussion forum, withdrawing a specific participant's data may be difficult. However, it is written in the information sheet and informed consent that withdrawal can only be made before one month after data collection. The discussion was also video recorded and one of the research assistants took a written report of the discussions, which could make it possible to trace the contributions of individuals.

E-mail interviews

E-mail interviews can be very valuable where respondents are geographically far apart, or for those who may not be easily accessible for face-to-face or telephone interviews (Meho, 2006). E-mail interviews can be a good option to reduce the disruption of school activities that may occur when only face-to-face/telephone interviews are used in school-based studies. This also eliminates the interviewer's effect; transcription is also automatically done for a hundred per cent possibility of capturing the full content of the interview (Curasi, 2001). Facebook and email are readily accessible to most people in South-Western Nigeria. The limitations identified with the exploratory telephone interviews i.e. the protocol involved and the inability of the respondent to cross check data before given responses, necessitated the use of e-mail interviews.

Limitations of e-mail interviews

A major limitation of e-mail interviews is that non-spoken actions such as facial expressions or body language are not captured by e-mail/Facebook interviews **(**Schneider et al., 2002). Furthermore, email or Facebook interviews do not allow direct probing, as in face-to-face or telephone interviews, but this could still be done in subsequent follow-up e-mails. The insecurity of electronic files (Etter & Perneger, 2001) which is a major challenge of the confidentiality (Harwood (2007) assured by the researcher, is also a limitation of e-mail interviews; however, a strong password was used for the research document for security (Mario et al, 2011).

4.10.6. Stage 4: Description of study school 1

Demographics of study school 1

The demographics of the schools and participants are presented and discussed in this section. This is considered necessary to provide background information needed to understand the school settings, and will eventually be useful for understanding the discussion of findings in Chapter 8. The settings in a mainstream school have a great deal of impact on the learning and inclusiveness of the learners with visual impairment (Fazzi, 2014).

It is also a known fact that no two schools can be the same in everything. Schools may be affected by being under different head teachers or different local or state governments, and the type of staff and learners in the school cannot be the same. Therefore, the following sections present an overview of the facilities and the participants in study school 1.

Overview of the facilities

The school is one of the mainstream schools in Soho (pseudonym) State which is in South-Western Nigeria. It was established in 1980 as a co-educational school. It is located in Ayedire (pseudonym) local government area on six hectares of land in a remote area, five kilometres from the town of Ayedire. It is a full boarding school (all students live in the school), and became a mainstream school in the year 1996 following the passing into law of the inclusion of SEN in the state system. Specifically, this school mainstreams only students with visual impairment. The facility was upgraded under X project (pseudonym) by the immediate past governor of the state. The school electricity is supplied by solar energy built/fixed in two separate parts of the school, for the junior and senior schools respectively.

The school is divided into two sections, the junior and the senior secondary school within the same fenced compound but on separate areas of land. The two schools are joined by networks of roads beautifully surrounded with flowers. Each school has its own Principal and two Vice-principals (academic and administration). The junior secondary school final examination (Basic Education Certificate Examination [BECE]) is organised by each state (generally, in Nigeria) while the senior secondary school certificate examination is organised by the West African Examination Council (WAEC), and a separate one by National Examination Council (NECO). The school admits students to either junior or senior secondary section annually.

The senior secondary school is housed in a two-storey building and two one storey buildings separated by big fields that are networked by demarcated footpaths. There are separate laboratories for Physics, Chemistry, and Biology. Each laboratory has benches round the wall and two central benches. There are fifty laminated-top solid stools placed beside the benches in designated position for each user. Each laboratory can conveniently accommodate forty students at a time. The relevant science teacher's office is in a room next to, and linked with, the preparatory room and the laboratory. There are two computer laboratories each with more than twenty personal computers and an interactive board. There are twenty classrooms distributed into eight, six and six arms for classes SS1, SS2 and SS3 respectively. Each classroom has a range of thirty to forty students and is either science, arts, commercial or technical depending on the subject combination. Altogether, the population of the senior secondary school is 780 students. Amongst them are nine students with visual impairments. The solar energy supplying the senior secondary is located on the field between the blocks of classrooms. The Principal’s office includes the secretary’s office and a reception area for visitors.

The junior secondary section of the school occupies two thirds of the land. All the buildings are bungalows (no storey buildings). There is a single science laboratory, not up to the size of any of the senior secondary laboratories. It also has benches round the edges of the room and one in the centre. Two science teachers use the remaining laboratory space as an office. The resource room is next to the laboratory and it has two long benches, a few stools and a teacher’s table for the TVI. The SVI sit on the stools and put their brailler/Marburgs on the benches whenever they need to braille notes recorded on the tape, or they seek the assistance of a sighted classmate to read to them. There are a few Perkins Braillers on an open cabinet near the teacher’s table. There is a computer laboratory with thirty personal computers and an interactive board very close to the Principal’s office. There are five arms each for classes JS1, JS2, and JS3. Segregation into science, arts or commercial streams is not relevant at this stage because all the students are taught same subjects, but the JSS3 are allowed to choose two vocational subjects out of Business Studies, Home Economics, and Fine Arts just before the final junior secondary school examination (BECE). The population of the junior school is 605, out of which ten are with visual impairments. The solar energy plant for the junior school is also located in the centre of the buildings housing the junior schools. The Principal's office in the junior school and the Vice- principal's office have a common secretary. The offices and the classrooms are arranged and networked with demarcated footpaths. Altogether, 1.37% students of the school population have visual impairments.

Overview of the student participants

At the time of this study, there were 1385 students in the school and nineteen are students with visual impairment (SVI). The participants were SVI, science and mathematics teachers and sighted students from the classes observed. However, the teachers whose classroom lessons were observed were participants in the email interviews, while the SVI and their sighted classmates were the participants for the focus group discussion. Below are descriptions of the participants followed by a table that summarises the descriptions.

My decision, as indicated in my proposal, was to involve only Junior Secondary 3 students because they would be moving to the senior secondary where they would choose their career, and have experienced two years in the junior school. However, the situation I met in the schools influenced the choice of participants such that Senior Secondary 1 students joined the study in study school 1, and Junior Secondary 1 was involved in study school 2.

My first contact person in study school 1 led me to the office of the Principal of the senior school who immediately invited the SVI (those in the senior school) for a meeting in his office during part of the lunch break. He emphasised that they were looking for ways to include them in mathematics and the other areas of science that posed challenges to them. While opening the discussion at the meeting, the Principal said “It is particularly worrisome that visually impaired students who are known to perform well in other subjects could not sit for mathematics school and external examinations”. Invariably, the SVI in the senior secondary developed an interest, and eventually the two SVI in Senior Secondary 1, who were in their arts class, requested the Principal to permit them to shift to the science class for the few weeks of intervention, to have access to the resources. They were referred to the school career counsellor by the principal. Thereafter, I headed to the junior school Principal’s office, and it was amazing because he also requested his Vice-principal (academic) to invite SVI to his office. He said teachers complained to him on a daily basis that he needed to find a solution to the exclusion of the SVI in mathematics and other aspects of science, because they performed wonderfully well in the subjects they offer. The guidance counsellor said Wale, a junior secondary 3 SVI, especially had a keen interest in a science career. The meeting was similar to that of the senior school and I requested to observe Junior Secondary 3 for my study, but allowed the resources to be used for all the levels and subjects to avoid discouraging the other classes. Finally, I used the JSS3 as contained in the proposal and the two SVI in SS1. The demographics are presented below.

Table 4.2: Summary of the SVI participants' information in study school 1.

Students Name (pseudonym)	ID	Class	Age	Gender	Vision Status	Onset of VI	Preferred literacy medium	Additional disability
Tope	VI11	JSS3	18	Male	Totally blind	Congenital	Braille	No
Lekan	VI12	JSS3	19	Male	Totally blind	Age 3 years	Braille	No
Segun	VI13	JSS3	25	Male	Totally blind	1year	Braille	Autistic
Tinu	VI14	SS1	17	Male	Have Tunnel vision	Starting from age 5 deterioration progresses	His vision is not enough for learning. He uses sight and braille	No
Sade	VI15	SS1	23	Female	Totally blind	Congenital	Braille	No

The class has a regular seating plan which is always maintained, except when there is a disturbance, which may lead to a temporary or permanent shift of students within the same class or to another arm of the class. The ages of the SVI are greater than most students in their classroom because they were not registered in school early. Each State has only one special school for blind pupils and parents always feel reluctant to release their little child to a school far from their home. Therefore, it takes time before they put up courage to do so.

Table 4.3: Summary of the sighted peer participants' information in study school 1.

Students Name (pseudonym)	ID	Class	Age	Gender
Jide	S11	SS1	16	Male
Sade	S12	JSS3	15	Female
Sewa	S13	JSS3	16	Female
Tolu	S14	SS1	17	Female

Overview of the teacher participants

Five teachers were involved in the study in study school 1, four are subject teachers, and one a teacher of the visually impaired (TVI). These teachers teach junior secondary mathematics, senior secondary mathematics, basic science and chemistry.

The junior secondary mathematics teacher was a 40-year old university graduate of mathematics, and had been teaching mathematics for 20 years, but had spent nine years of his experience teaching in mainstream schools. He had no training about how to teach visually impaired students. He was a member of the Mathematical Association of Nigeria (MAN). He reported to have attended trainings and conferences organised by MAN but none had included presentations /workshops on how to include the visually impaired in mathematics.

The basic science teacher was 31 years old and had a Bachelor of Education degree in Integrated Science and a diploma in computer science. She had been teaching in a mainstream classroom for up to six years. She belonged to the Science Teachers Association of Nigeria (STAN). She also reported to be participating actively in the local and national activities (training and conferences). However, none of the training has included ways of including the visually impaired in specific areas (drawing, graphing and calculations) and laboratory activities.

Similarly, the chemistry teacher was a 35-year old lady who had a Bachelor of Science degree in chemistry, and a diploma certificate in computer science. She started her career in that school about eight years ago. She had no training on techniques of teaching the visually impaired, but claimed that she never had anyone visually impaired in her class. She was also an active member of STAN.

The mathematics teacher in the senior secondary school was 36 years old. She held a Bachelor of Science degree in mathematics. She started her career in that school ten years ago. She was a member of STAN and MAN and currently an executive member of one of the associations (Ethics). She reported to have attended and organised training and workshops in mathematics, but had not done that for the visually impaired as the general belief was that it was impossible for them to do most parts of mathematics, so it was always recommended that they should be given exemption.

Finally, (TVI), the teacher of the visually impaired in the school was a lady of 30 years old. She graduated from the Federal College of Education (Sp) Oyo. She was also visually impaired. She taught the SVI in the school braille and produced braille examination questions for both the junior and the senior schools. She always required someone dictating the questions to her. She was a mentor to all the visually impaired in the school. They saw her as the guardian of all the visually impaired in the school. She sometimes converted students' work to print by producing the print version on a computer or typewriter. She had difficulty representing mathematical concepts or drawings as she herself was not taught when she was in secondary school. She was not taught how to teach mathematics and calculations to visually impaired during her training in the college.

Table 4.4: Demographics of teacher participants in study school 1

Name	ID	Sex	Age	Qualifications	Vision Status	Teaching experience	Special Education training	Professional activities	Subject/class taught
Mr Oke	CS101	M	40	1.BSc Mathematics 2.Post graduate degree in education (PGDE)	Sighted	20 years (9 of them in mainstream school)	No training in special education	Participates actively in MAN workshops and conferences	Mathematics/JSS3
Mrs Olowo	CS102	F	31	1. Bachelor of Education (B.Ed.) Integrated Science 2. Diploma in Computer Science	Sighted	6 years	Has no training. Has never attended any	Attended Integrated Science group workshop and annual conference of STAN	Basic science/JSS 3
Mrs Musa	CS103	F	35	1. BSc Chemistry 2. PGDE 3. Diploma in Computer science	Sighted	8 years	No training on ways of teaching visually impaired	Active member and executive member of STAN chemistry group	Chemistry/SS1
Mrs Ade	CS104	F	36	1.BSc Mathematics 2. PGDE 3. Diploma in Computer Science	Sighted	10 years	No training	MAN and STAN	Mathematics/SS3
Mrs Kate	CS105	F	30	NCE special education combined with Christian religious studies	Blind	7 years	Had training to teach visually impaired but inclusion in science and mathematics is not part of what she was taught. She remembers Nemeth code was mentioned in one of the special education courses		TVI

Description of the classroom and laboratory context in study school 1

Study school 1 was chosen because of the available facilities in the school, as explained in earlier section of this report. There are three separate laboratories in the senior school each specifically designed and equipped in relevance to the subject, either Physics, Chemistry or Biology. The chemistry laboratory was used for the intervention in the senior secondary as agreed upon at the meeting with the teachers.

The laboratory is a large room that is 35 feet by 30 feet in dimension. It has two adjoining offices, the front one is the teacher’s and technician’s, office and the next one is the preparatory room where reagents are prepared before the practical. The preparatory room is bigger than the teacher’s office and it has a small store attached to it on the other side. The equipment is kept in shelves in different lockers in the store. There are benches fixed to the edges of the laboratory room and two wider benches were fixed in the middle. The bench in the front of the class is elevated higher than the rest to make it possible for students to observe demonstrations during the lessons. Reagent racks are fixed at regular interval visible and close to students working on all sides of the benches. The benches have a small sink and a gas valve and strip electrical outlets are fixed at regular intervals, corresponding to the required need and the length of the bench. All the benches have storage lockers fixed appropriately to spaces designed for one student. These store equipment/salts that are commonly/regularly used and are not corrosive. The surface of the bench is dark coloured and is made of durable material because of the chemicals, and are stain resistant with a laminated top. There is enough space that allows free movement of users (students and staff). The school has many safety googles to be worn during experiments

The laboratory is well ventilated, as it has seven wide windows at opposite sides and there are also relevant posters on the wall for sighted students. The liquid waste removal design is also well constructed and water runs from all the taps because it receives supplies from the borehole supplying the entire school, which is also well maintained.

However, there are no water deionizer, fume cupboard, or adequate safety equipment (they only have a first aid box, a fire extinguisher and a fire blanket), as there are no emergency shower and eyewash station among other safety devices.

In terms of its suitability for the SVI, the laboratory as it is can be used with little adaptation. For instance, there is need for provision of trays which serve as the working station where all materials to be used by SVI should be placed. It was provided during all the periods of this study for the SVI, and the sighted groupmates worked together with it.

The junior secondary laboratory is not like the senior school laboratory just described. It is a multipurpose laboratory used for all Science subjects taught in the junior school. All the junior schools have just one laboratory. It is also spacious, has benches and lockers like the senior secondary, but it was not presented well. The benches were just tables (not coloured and not laminated) no sink, no electrical outlets on the table except few on the wall and of course no running water and no liquid waste disposal fixed in the laboratory. It also has very few windows (three) so it is not well ventilated. There are no reagent racks, no preparatory rooms and no teachers' or technician's office as two teachers used part of the laboratory as their office. There is a big open cabinet on one side of the laboratory where a few pieces of equipment and reagents are kept.

4.10.7. Stage 4: Description of study school 2

Demographics of study school 2

The context of study school 2 is covered under this section. Information such as the school facilities, overview of the participants (students and teachers) is given. . This is particularly useful in describing "the real-life context in which an intervention has occurred" Yin (1984, p.25).

Overview of the facilities

This school is in a different state in South-Western Nigeria. The school was also established in 1980 and it was situated on three hectares of land in the middle of the city of Ibagan (pseudonym) in Ibala local government area. The school is also a co-educational, day and boarding school. The school is divided into two sections like study school 1 (the junior and senior school) each headed by a Principal. There is a partial fence round the senior school and the junior school is open, as people pass through the compound any time of the day. The junior secondary final examination is conducted by the state and the final senior secondary examination is conducted by WAEC and NECO, the examining bodies, as in study school 1.

The senior secondary is housed in one two-storey building with a dilapidated roof and another storey building and three other widely scattered bungalows. The buildings are not painted and the footpaths are not properly networked for easy access by SVI. There are three separate laboratories for Physics, Chemistry and Biology.

There is one small computer laboratory used by the junior and senior schools. The size and content was like the one in study school 1 junior school, but without the interactive board. There are more than thirty classrooms in the senior school alone. SS1 to 3 are each divided into eight arms, and there are 35 to 40 in each of the classrooms, making the school population in the senior school to be 902, which includes 21 students with visual impairments. There are three arms of science and arts and two arms of commercial classroom in each level. There is a reception area in the Principal's secretary's office and a generator, which is used when there is power failure, is kept at a conspicuous position in the secretary's office.

The junior secondary section of the school is located on half of the land and it is a very long semi-detached one storey building. There is also one small poorly furnished separate laboratory for the junior school. There are 10, 9, 10 arms for JSS1, JSS2 and JSS3 respectively. There is also no segregation into arts science and commercial streams because, like in study school 1 student do all subjects and only select two out of the vocational subjects (home economics, business studies and fine arts) before the final junior school examination which is also conducted by the state as in study school 1. The total population of the junior school is 1015. Amongst them are 20 students with visual impairment. The

Principal's office is the first room in the first floor of the building, and also has a secretary's office. There is no network of roads/footpaths clearly demarcated in the school, but the steps and the veranda are very wide and guarded with strong rails.

Overview of participants in study school 2

The participants for the e-mail interview in study school 2 were three teachers: the TVI, science and mathematics teachers. The student participants were the SVI in JSS 1 and 3, and also sample sighted in their classes. Each participant was given a pseudonym and identification, for example CS201 to CS203 for study school 2 teachers. The two subject teachers are sighted, but the TVI in study school 2 has low vision. The tables below show a summary of the information on the participants.

Overview of the SVI participants

Out of the 1917 students in the school, 2.1% were SVI as at the time of this study. The situation in study school 2 was different in some aspects from study school 1 – a further example of why the context is as important as the phenomenon and they are inseparable. The Principal of the junior secondary school was my first point of contact the first day I visited. He remembered me outright and asked me, "Madam! Are you here with the resources? Because the issue of visually impaired not doing mathematics comes up in every meeting held in the school!" I said "Yes" and he stood up and led me to the Principal of the senior school. He also remembered me because the search conference organised for that state came up in their school and both Principals took part in the conference.

I thanked them and explained the stage of the research, and what was requested from teachers, SVI and the school. I requested them to help me to distribute the information sheets and the informed consent forms, and that they should collect the slip signed by each participant to show consent. It was amazing to know that none of the participants rejected taking part in the research. They all returned the slip. At the meeting with the two Principals and the mathematics and science teachers it was agreed that we should use Junior Secondary 1 for mathematics because the remaining classes might not cope with the teaching, and JSS3 for the basic science, although all of them were interested. Therefore, I agreed that the resources could be used for other classes but they would not be considered as part of the study. The detailed information on the SVI participants is shown below.

Table 4.5: Summary of SVI participants' information in study school 2.

Student Name (pseudonym)	ID	Class	Age	Gender	Vision Status	Onset of VI	Preferred literacy medium	Additional disability
Opeyemi	VI21	JSS3	25	Male	Totally blind	Mid-primary school age 8 years	Braille	No
Jadesola	VI22	JSS3	20	Female	Totally blind	Totally blind since childhood	Braille	No
Maryam	VI23	JSS3	23	Female	Totally blind	Congenital	Braille	No
Jolade	VI24	JSS3	19	Female	Totally blind	Age 3	Braille	No
Joseph	VI25	JSS1	20	Male	Has limited vision (braille reader)	Don't know	Braille	No
Ade	VI26	JSS1	17	Male	Totally blind	Congenital	Braille	No
Adediran	VI27	JSS1	17	Male	Totally blind	From birth	Braille	No

Table 4.6: Summary of the sighted peers participants' information in study school 2.

Students Name (pseudonym)	ID	Class	Age	Gender
Titi	S21	JSS1	15	Female
Ade	S22	JSS1	14	Male
Joke	S23	JSS1	14	Female
Tolulope	S24	JSS3	15	Male
Yinka	S25	JSS3	17	Female
Jumoke	S26	JSS3	16	Female

Overview of teacher participants

The basic science teacher in Amos Community Commercial Grammar School studied Physics at a Nigerian university and had been teaching basic science and mathematics about 15 years in that school. He was 38 years old and a member of the Science Teachers Association of Nigeria (STAN) and the Mathematical Association of Nigeria (MAN). He had no training on techniques of teaching mathematics or sciences to the visually impaired.

Similarly, the mathematics teacher in charge of junior class 1 was 33 years old. He had a BSc degree in mathematics and had been teaching mathematics in different classes in the school since he joined Amos study school 1 10 years before. He was also a member of MAN. He was even a State executive. He had no training of how to involve SVI in mathematics or science.

Finally, the 40 year old TVI in the school graduated from a University in Nigeria with a second class upper division degree in special education. He majored in education of the visually impaired and English, and had worked for 15 years in the school. He had some useful vision, as he moved round the school without a mobility cane and sighted assistant, but he reported that his vision was not enough to read print. He produced brailled questions for the school examinations, and trained new students on mobility after school hours during the first term of the student in the school. He was receiving support from other teachers of other subjects who graduated from Federal College of Education Special, Oyo who also majored in visually impaired education. He was the counsellor of the SVI in both junior and senior schools. The table below summarises the demographics of the teacher participants in study school 2.

Table 4.7: Demographics of teacher participants in study school 2

Name	ID	Sex	Age	Qualifications	Vision Status	Teaching experience	Special Education training	Professional activities	Subject/class taught
Aperin	CS201	M	38	BSc Physics	Sighted	15	No	STAN and MAN	Basic science/JSS 3
Hassan	CS202	M	33	BSc Mathematics	Sighted	10	No	MAN	Mathematics/JSS 1
Oniyere	CS203	M	40	BA in ENG/SVI	Low vision	15	Yes		TVI

4.10.8. Stage 5: Data collection procedure (both study schools)

This will be discussed in detail for each study school because of the different context existing in the two schools. Before the main data collection procedure, initial observation was conducted. This section also presents the procedure for the training in the study schools, because the training was conducted as the first stage in the interventions. The procedure followed while using each of the methods for data collection is also presented in this section.

Data collection procedure in the study schools

Three methods of data collection earlier explained were used. The procedures followed in conducting each method in both schools are similar. They are presented one after the other, observations in study school 1 is followed by email interviews and focus group discussions for each study schools. Before the data collection, an initial observation was conducted in both study schools.

Observation of lessons

Initial observation of lessons

In order to have a fair basis for comparing the participation of SVI during science and mathematics lessons, I conducted initial observations before the training. Although unstructured, This observation is expected to be an assessment of how science and mathematics is taught before introducing the resources. Before the observation days, I collected the subjects’ periods in the school time table to know when the subjects are taught in those classes. Being aware of the researcher biases earlier discussed, I involved the research assistants in the observations. We observed the same lessons and recorded videos of the observed lessons with a pen recorder. After the day's observation we sat in the school, watched the recorded video and compared our observation schedule immediately or after school hours to avoid memory selection, and I adopted the agreed observation schedule for the study. The agreed schedule was made available to the teacher that was observed, and we considered their comments. Most times they agreed with our agreed schedule.

A total of ten lessons were observed in study school 1, two each for junior secondary mathematics and basic science, senior secondary mathematics, chemistry theory and practical. The activities were observed for periods of 40 minutes for each subject, as the school time table indicated. Six lessons were observed in study school 2, three each in JSS1 and 3. The teacher introduced me and the research assistants to the students as a friend of the school and particularly emphasized that I am a scientist who is interested in enhancing the participation of SVI in mathematics and sciences, which is a concern for them as well. "She is here to work with us in the classroom with her team. She may need to take pictures or record videos of the lessons for the purpose earlier explained". It is important to note that none of the students and teachers refused to participate. In fact, the slip was returned the same day by those over 18 years of age, and the only one under 18 SVI contacted his parent over telephone. The school guardian of all the sighted under 18 years of age signed the slip, after contacting and seeking approval to participate from their parents on telephone.

Observation in Study school 1

During the observation, six attributes were selected for observation. The participation and dependence of students with visual impairment in the class activities was observed. Attention was paid to comparing their roles when joined with the sighted students in group science activities with when they worked alone. How well did they use the tools during the lessons? Thirdly, the frequency of seeking sighted assistance was observed, to see if the SVI were given opportunity to be independent, and also if they were confident. Fourthly, the main difficulties faced by the SVI and how they manage the difficulties were also observed to discover whether there were any accidents, any spillage of chemicals or injuries and fire incidents. Lastly, it was observed whether there were differences in the participation of SVI with different levels of ECC competency, and the social interaction between the SVI and their sighted classmates was also observed.

The period allocated to basic science and mathematics in the schools was extracted from the school timetable before the observations.

Classroom observations (when teaching with the resources) were also video-recorded, to capture the activities and interactions in detail, and so as not to miss out key moments. Distraction of teachers and students was avoided, and the recording instrument was inconspicuous so as not to deceive them. However, they were told the lessons would be recorded. The observations were repeated up to three times in the same class. Since the teacher is considered a co-researcher in action research, a cordial relationship was maintained with the participants.

The two research assistants (one TVI and one mobility specialist) recruited assessed the ECC competency.

The observation schedule (see Appendix VIa) was used as a guide during the classroom observations.

Procedure followed during focus group discussions

Focus group discussions were held in the study schools after the intervention, to get in-depth and rich data about students' experiences. This method is particularly suitable, as the number of students involved is not expected to be large. The aim of the discussions was explained to the participating students, opportunity was given for introductions and familiarisation. To maintain confidentiality, they were informed to use a pseudonym before introducing themselves. The discussions lasted about an hour. Statements that helped achieved a balanced participation was used. (See Appendix VIb and VIc for the focus group guides).

The aim of the focus group is not to elicit individual opinions as in a one-to-one interview; rather, the processes of communication and agreement and disagreement between members of the group encourage participants to analyse their accounts and opinions more intensely, and therefore provide a more accurate account (Millward, 1995).

Before commencing the focus group discussions each time, I always stopped and asked the recorder (first research assistant) to play back the video after creating the required atmosphere for the discussion, to be sure the discussion was recorded and that it was audible enough. I started all over once the recording device was confirmed as working properly. This, I noticed, also gave some participants confidence. The second research assistant was positioned in one corner of the venue, assigned to write down the discussions. He was instructed to record group dynamics and body language that might not be captured in the recording.

The participants were encouraged to talk one at a time and as clearly as possible. They were reminded of the ethical considerations that they were free to use pseudonyms and could withdraw at any time, but I realised they all used their own names, and that they were happy to be associated with the research. They were asked to respect one another during the discussion, although there was room to disagree among ourselves. The following rules were agreed upon before commencing the discussions: to avoid the use of “you are wrong” – instead, “I agree” or “I disagree” should be used; our comments and discussions should be on the topic I raised as the moderator of the discussions; members should treat our discussions confidentially; we should be free to express our opinion even if it is different from others’, because there is no right or wrong; we should allow one person to talk at a time; all mobile phones should be put in silent mode.

The focus group discussion in study school 1 took place at the junior secondary science laboratory after school hours, but immediately after their lunch. This was their choice of time and venue, and it involved only the SVI involved in the research. The discussion was announced to the sighted classmates that volunteered, and it was suggested that they should join the researcher in the junior school science laboratory. The turnout was more than thirty, so I decided to randomly pick four participants. (Only four “YES” were written on small papers mixed in a bowl presented to the sighted classmates). The discussions with the randomly selected sighted classmates also took place in the same venue, after that of the SVI.

All the students contributed throughout the discussion, but the strength of the discussion was not much possibly because of their ages. I however considered it appropriate for their level. They related well with each other despite wide gaps in the ages of the SVI participants, there was no use of offensive words; even when Tope disagreed with Tinu on what loss of tiles could cause, the way it was said was polite and Tinu also agreed. The way they interacted encouraged participation. Their different levels in school did not show in their interactions, even slightly. There was mutual respect and cooperation among the group.

A research assistant was requested to write during the discussions, and a video recording was also taken by the second research assistant during the four focus groups. Two were organised in each of the schools, one for all the SVI and the second one for sampled sighted classmates. Transcription of the focus group discussions was done over some days, and by two different people, the research assistant and myself as the lead researcher. Before the transcription, we discussed common terms and styles to be used, and we agreed to first write it out word for word.

Transcriptions of the video

The transcription was done by me and the research assistant, and the transcripts were compared. We also replayed each video before arriving at transcripts for each of the discussions. Before the actual transcription, we studied and adopted the recommendations of Silverman (1998, 2013), on the process of transcription. We agreed on the following: To put '()' when there was empty talk or when it was too obscure to transcribe; '[ ]' indicated the transcriber's best estimate of what was being said; 'hhh' for ordinary breathing /laughing; 'o' for lower in volume than surrounding talk; ‘x’ for faster than surrounding talk; and ‘(( ))’ for the transcriber’s comments.

The transcript was taken back to the school and was read to the participants during the short break and part of the long break. A printed copy was also made available to the sighted participants, and a brailled copy was made available to the SVI participants for them to confirm the correctness of the transcript. There were few corrections, and the final draft (authenticated versions) was uploaded to the thesis NVivo file and was analysed. The procedure for analysis is presented in another part of this chapter.

Procedure for e-mail Interviews

E-mail interviews were conducted for all the teachers of basic science and mathematics in the two study schools (see Appendix VId for the e-mail interview schedule). An email containing the information about the research was sent to them. They had already signed informed consent before the observation of the lessons. As explained earlier, there are various methods of conducting e-mail interviews, from the literature; the idea of sending all the questions with the information and informed consent form (Murray and Harrison, 2004), was neither proven to be superior or more effective than sending the questions one after the other (Kim et al., 2003). The preferred procedure depends on the participants, the researcher and the length of the interview (Meho, 2006). The questions for this study were embedded in the body of the email. Curasi (2001), and Dommeyer & Moriarty (2000), reported that the response rate was five times higher when the interview questions are embedded in the body of the email than when sent as an attachment. Downloading may be a problem for some mobile phones which lack applications that could enable the download of documents.

Methodological considerations of e-mail Interviews

The data generated from the e-mail interviews required no transcription, as they were just copied and pasted in NVivo for analysis. Similarly, no further confirmation of the data was required after downloading. The responses showed the exact expressions of the participants without researcher's reorganisation. This form of data collection allowed respondents to check the clarity of every word in the email before sending it to the researcher; no rushing was required, as in telephone interviews, since respondents can respond over time. Responses can be saved as Microsoft word documents, or be saved as drafts (if questions are embedded in the body of the e-mail) until all the questions are responded to. The cost when compared to the postal questionnaire used in the exploratory study is also very low. It is also cheap when compared with face-to-face interviews; the stress is also reduced greatly.

However, it is not possible for the researcher to ask further questions if the responses are unclear, or questions are not fully answered, as I noticed in some of the responses where some parts of the questions were not answered. In this study, the unanswered parts were considered as undecided or as deliberately not answered.

4.10.9. Stage 6: Data analysis procedure

The analysis of findings from the study followed the thematic structure done by the researcher using qualitative data analysis. The data analysis techniques used are both manual, and a software package. The analysis took place at different stages of the study; for the exploratory study, a combination of qualitative and quantitative analysis was done. However, qualitative data were collected during the search conferences, and during evaluation of resources in the study schools. In agreement with Rubin and Rubin (1995), analysis of such data is continuously done as the study progresses. Such continuous analysis allowed scrutiny of collected data, as they were collected and analysis commenced as the data were collected, because of the open-ended nature of the design. Data collected during some stages influenced the direction of the research. For example, some findings of the search conferences influenced the choice of study schools, and the resources for intervention among other things. Thematic analysis was used at the different stages of the study, and while using each of the data collection methods. Concepts and themes were identified and explored by subjective interpretations of the data collected.

The observation schedule and focus group guides are semi-structured, allowing other salient points to be explored further than planned in the focus group discussions and recorded during observations.

Manual analysis

Manual analysis was done on the data by analysing, preparing transcripts, checking accuracy of the data through participants' checking and making sense of the data. This follows a deductive approach, allowing themes to emerge from the data. The sample, resources used and even the direction followed by the research emerged from the data to portray the deductive analysis involved.

In addition, manual analysis was adopted for analysing the observation data. Each focus group discussion was also analysed through manual analysis, deducting from the conduct of the discussion. The strength of the discussion was also identified among the group members: were there disagreements? Or did they reach consensus on issues? Was there shared understanding? Was there any influence on the ECC competency of the SVI?

Software analysis

An NVivo software package was used in the analysis of data from interviews and the transcript of the focus group discussions. This was adopted to improve organisation and analysis of the data. There are many such software packages, but NVivo was considered as I had opportunity to register for free courses on NVivo in the Centre for Learning and Development (CLAD) in the university.

Each set of interview data was input into Microsoft word documents, and these were uploaded into the NVivo project file created for this thesis. Before uploading, a separate source documents folder was created for each school, and for each participant, which enabled respective documents to be uploaded to respective folders. That meant within the folders were also created subfolders. For example, separate interview folders were created for Study Schools 1 and 2. Subfolders were also created for individual interviewees in each school. Thereafter, attributes were assigned on the interviewee’s, gender, role, teaching experience, qualifications, relevant training experience, vision status etc. The same process was followed for focus group discussions transcripts. This allowed searches to be conducted on the data collected from different methods.

Coding the search conference data, e-mail Interview and focus group discussion data

This section presents the process of analysis of interview and focus group data. I approached the data gathered by reading through the responses and the questions up to five times each to de-contextualise the responses. The questions surrounded the areas of interest as they took the format of a semi-structured interview.

A node represents categories identified by researcher during the process of coding. Depending on the contents of the data, a node may represent persons, concept, ideas or any other thing (Richards, 2000). A code is considered as an abstract representation of objects or phenomena (Corbin and Strauss, 2008:66). Therefore, text from the data is coded and allocated to relevant nodes during the analysis. The nodes can be parent node or child node, and can also form a tree shape having numerous nodes and sub-nodes attached to parent nodes.

Several of the hierarchical nodes and sub-nodes were formed during analysis of the search conference data, e-mail interviews and the focus group data. With these, analysis patterns were formed. For example, six themes were created as nodes initially from e-mail interview data. But as the coding continued the node increased to twelve. With further analysis, and especially by focusing on the purpose of the interview and the research question, some nodes were merged or made as child nodes, some were deleted. Thereafter, seven themes eventually emerged. The figure below illustrates the nodes and sub-nodes generated from search conference data.

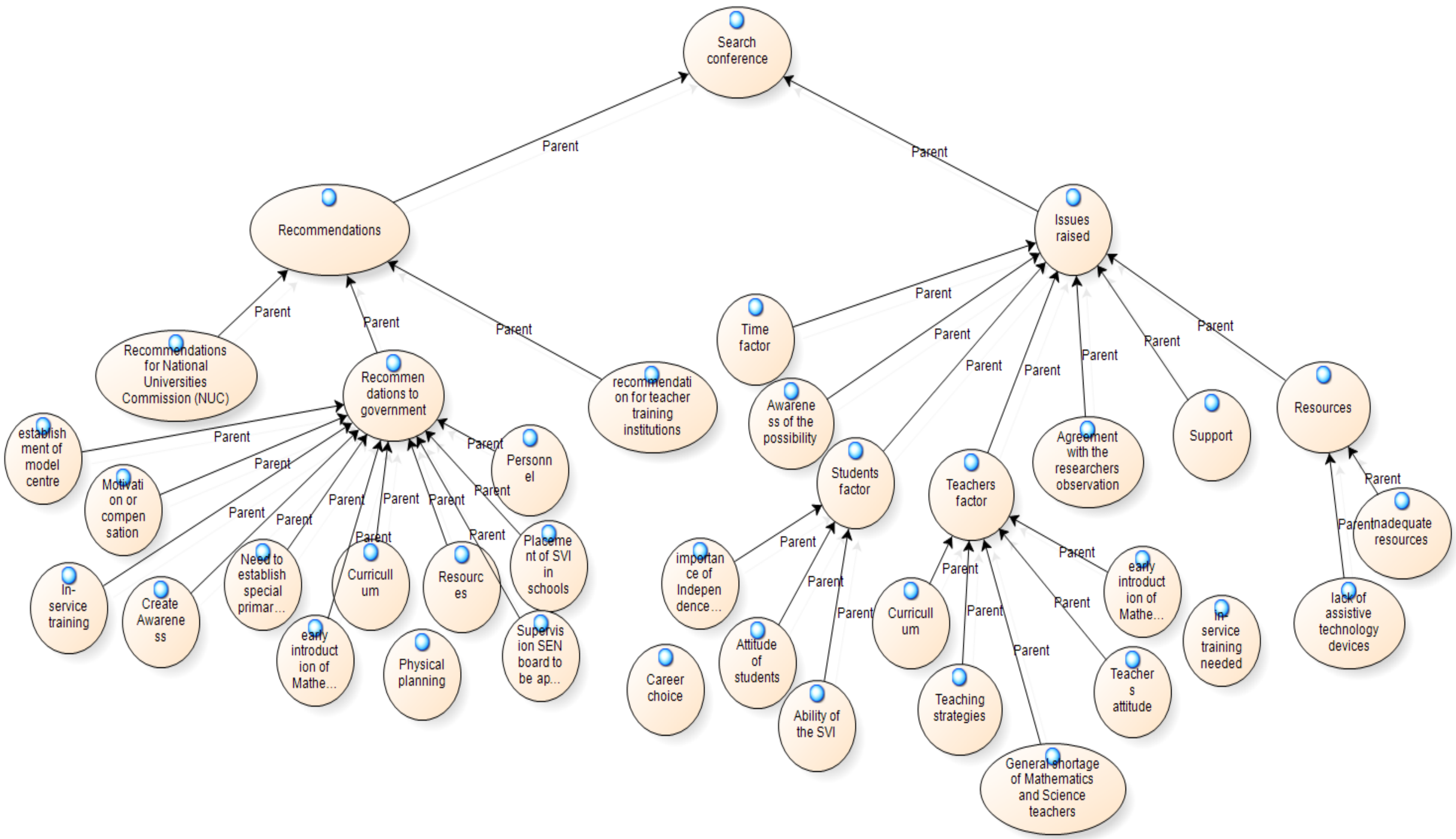


Figure 4.6 Model of the nodes and sub-nodes from search conference data

Issues and recommendations are the immediate child nodes, recommendations for the teacher training institutions and for the National Universities commission appear as free nodes, having no sub-nodes/child nodes, while recommendations to government have twelve child nodes as shown in the figure below.

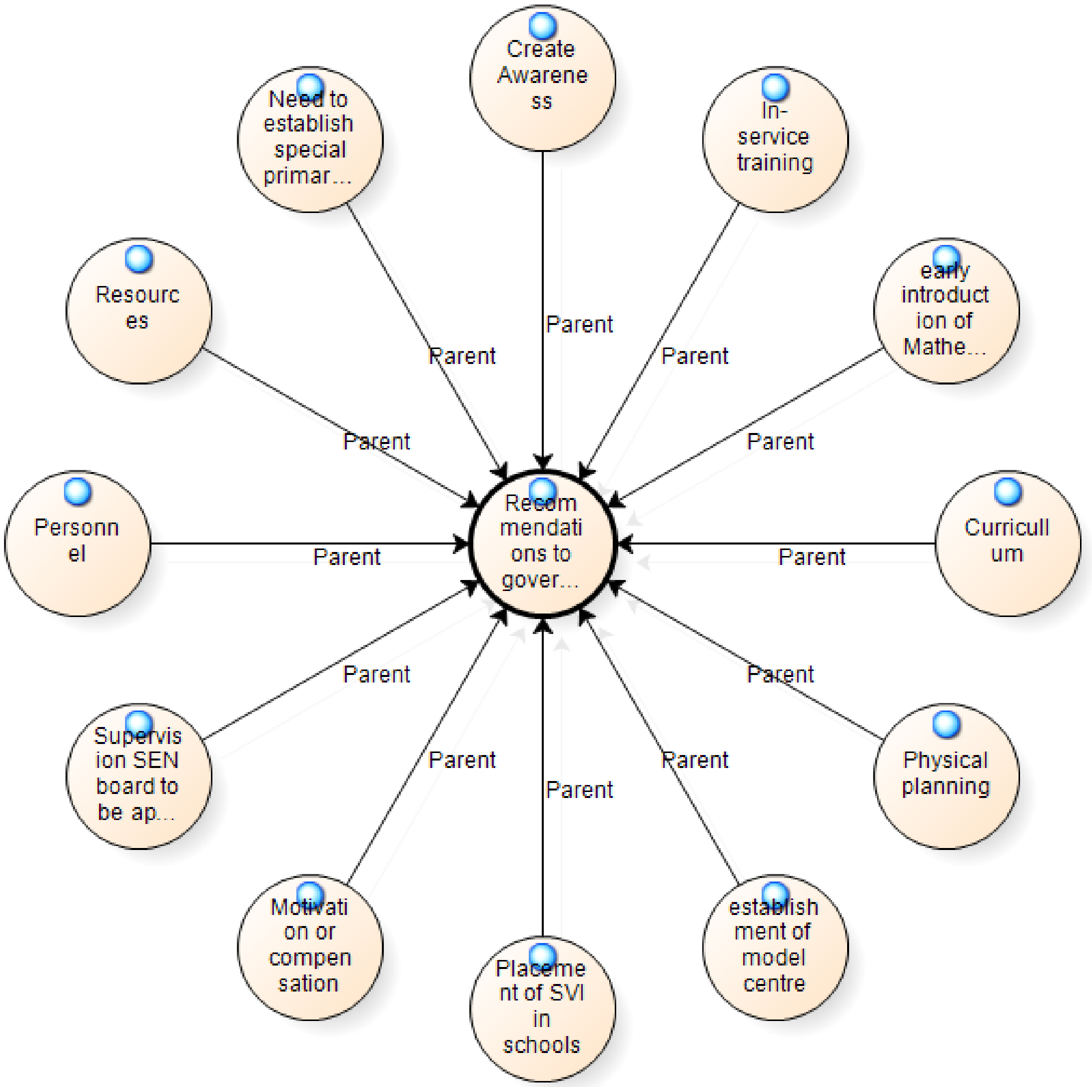


Figure 4.7: Model of recommendation to government and its sub-nodes.

Sometimes child nodes are further categorised, for example *issues raised* was a child node of the search conferences, similarly *student's factor* is a child node of the issues raised. Furthermore, *importance of independence, career choice, student's attitude* and *ability of the SVI* are also child nodes of the student's factor.

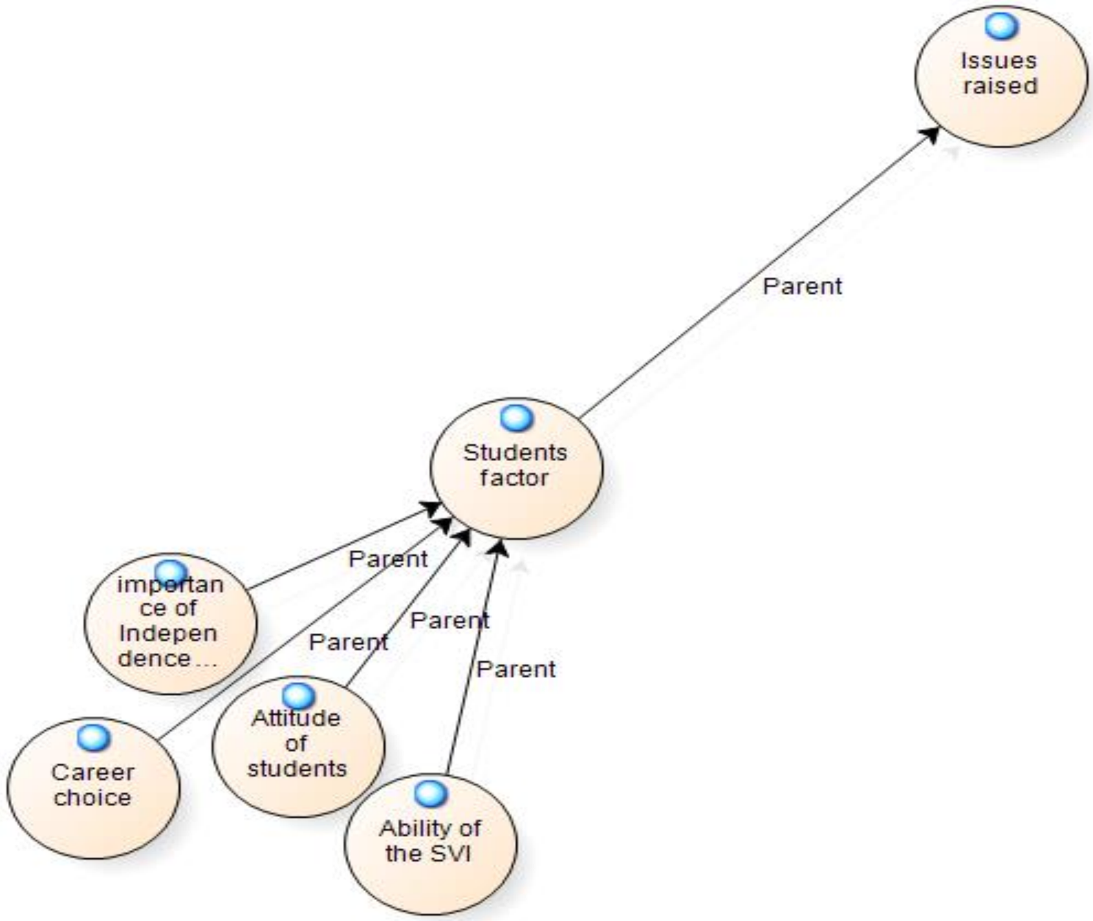


Figure 4.8: Child nodes and great grandchildren nodes

The query wizard (text search and word frequency search) was used for some keyword searches and the findings were presented and discussed under the appropriate theme, and the findings were supported with excerpts from the data as shown in Chapter 6 and 7. The explore tool in NVivo was also used to represent some findings in models/chart figures; The overall discussions of the findings linked with literature is also presented in Chapter 8.

The reason for, and benefits and process of triangulation in this study

Triangulation in research is a controversial term/phenomenon, often considered a powerful technique for improving validity in research through cross-verification of findings from two or more sources. That is, studying/exploring the same phenomenon either with a different method (methodological triangulation) or a different researcher/observer (analyst triangulation) or using multiple theoretical perspectives (theory/perspective triangulation), a different point in time or different viewpoints (triangulation of sources). Some researchers believe a phenomenon cannot be appropriately studied in a single way because all ways have potential demerit which might be addressed when a phenomenon is studied in more than one way. Hence the reason for triangulation is to have opportunity to study the phenomenon deeper enough. However, in qualitative study, triangulation is used to obtain rich, robust, comprehensive and well-developed data (Denzin, 1978; Patton, 1999). In a nutshell,

> "By combining multiple observers, theories, methods, and empirical materials, researchers can hope to overcome the weakness or intrinsic biases and the problems that come from single-method, single-observer, single-theory studies. Often the purpose of triangulation in specific contexts is to obtain confirmation of findings through convergence of different perspectives. The point at which the perspectives converge is seen to represent reality." Jakob (2001)

Triangulation in this study was used to achieve both reasons:

1. To verify data obtained through different data sources.
2. To obtain rich, robust and comprehensive data.

The process of triangulation involves cross-analysing findings from two or more sources, methods, observers etc. depending on the form of triangulation used in a study. Triangulation can also occur during the process of data collection, whereby more than one source or observer could be used to collect data and the data collected by different observers compared, and the agreed data adopted for the study.

In this study, data collected by the research assistants, and the scribe during focus group discussion and during observations were compared, and the agreed data was adopted for the study. Similarly, data obtained through e-mail interviews, focus group discussions and observations were cross-analysed. The idea was not to obtain the same data, but to obtain rich and comprehensive data. The triangulation of findings from the three methods is presented for each of the Schools in Chapters 6 and 7.

4.10.10. Stage 7: Re-planning: Feedback to stakeholders and dissemination of findings

This represents the thesis recommendations which are presented in 8.7 of this thesis. An NGO (Science and technology for Nigeria persons with special needs initiative) was formed and registered with the Nigeria government. For further dissemination of findings of this thesis the NGO proposed an international conference covering more than the South Western Nigeria (which eventually took place in August 2016 in Abuja, after this thesis was submitted).

4.11. Research credibility, transferability, dependability and confirmability (validity and reliability)

Validity and *reliability* are terms used in quantitative studies to assess the quality of research, while qualitative researchers adopt *accuracy, credibility* and *dependability*. It is very much related to the researcher's ontology and epistemology. Different circumstances or purposes have ignited the research, and providing prepared answers may not achieve the object of the research, since participants may require the meanings to be explained. The participants' use of language or their context may not be adequately addressed by quantitative techniques. Below are methods of achieving a valid and credible qualitative study, listed by Seale and Silverman (1997):

1. Using a quasi-statistical approach
2. Ensuring representativeness of cases (using qualitative and quantitative approach) and recognition of merits of random sampling
3. Considering testing hypothesis by noting deviant case analysis
4. Using computer programmes to analyse data
5. Recording data objectively and comprehensively, ensuring detailed transcript is produced

In as much as the authors are held in high esteem in the field of qualitative research, some of the points raised can be argued. Attempting to use quantitative research as a yardstick for assessing qualitative research might end up not achieving the reason /purpose for the qualitative study. In the light of this, many naturalistic researchers prefer using different criteria to assess the quality of qualitative studies (Shenton 2004). In quantitative studies *validity* and *reliability* are associated with rigour whereas in qualitative research it is different. Guba proposes four criteria in preference to the criteria used for assessing the quality of quantitative research. The criteria are widely accepted by many qualitative researchers. They are: a) *credibility* (in preference to *internal validity*); b) transferability (in preference to *external validity/generalisability*); c) *dependability* (in preference to *reliability*); d) *confirmability* (in preference to *objectivity*).

Table 4.8: Provisions that may be made by a qualitative researcher wishing to address Guba's four criteria for trustworthiness [taken from Shenton (2004: 73)]

Quality criterion	Possible provision made by researcher
Credibility	Adoption of appropriate, well recognised research methods. Development of early familiarity with culture of participating organisations. Random sampling of individuals serving as informants. Triangulation via use of different methods, different types of informants and different sites. Tactics to help ensure honesty in informants. Iterative questioning in data collection dialogues. Negative case analysis. Debriefing sessions between researcher and superiors. Peer scrutiny of project. Use of "reflective commentary". Description of background, qualifications and experience of the researcher. Member checks of data collected and interpretations/theories formed. "Thick description" of phenomenon under scrutiny. Examination of previous research to frame findings
Transferability	Provision of background data to establish context of study and detailed description of phenomenon in question to allow comparisons to be made
Dependability	Employment of "overlapping methods". In-depth methodological description to allow study to be repeated
Confirmability	Triangulation to reduce effect of investigator bias. Admission of researcher's beliefs and assumptions. Recognition of shortcomings in study's methods and their potential effects. In-depth methodological description to allow integrity of research results to be scrutinised. Use of diagrams to demonstrate "audit trail"

Action research "meets criteria of validity testing more effectively than most of the other social research approaches, because it tests knowledge in action done by the stakeholders who will benefit from the research" (Brydon-Miller et al 2003). Rigour in AR is considered in a broader sense, not just regarding data collection, but on the entire research procedure. that results are not biased, reflecting not only the perspectives of the researcher (Stringer, 2007) but the perceptions of the participants. What matters is the improvement/change not the study rigour defined by ability to generalise its findings

AR is considered a valid research approach because of its participatory/collaborative nature and its use of many criteria Stringer, (2007). As shown in the table, polyangulation of data from multiple sources can enhanced the rigour/credibility of the research (Patton, 1990; Yin, 2003) because the action researcher can cross check the accuracy of the data (Mills, 2011) and also clarify meaning and misconceptions in the study findings (Stringer, 2007). Member checking is another way to enhance rigour in the studies, participants should be allowed to check findings at different stages of the study (Mills, 2011; Stringer 2007)

4.12. How rigour was ensured in this study

The table below summarise how rigour was ensured in this study

Table 4.9: How rigour was ensured in this study

Quality criterion	How rigour was ensured
Credibility	As action research, participants were involved from the onset. There was early familiarity between the lead researcher and the co-researchers even before the search conference and during and after the conferences; The sighted participants were randomly selected for the focus group discussions in both study schools Three known methods of gathering data was adopted, Classroom observation, E-mail interview and Focus group discussions; There was also triangulation of data gathered from the three methods in each study school, from different types of informant/participants and from two different sites (study schools 1 and 2); There were debriefing during different stage of data collection. After the focus group discussions and after observations of lessons. The e-mail interview requires no debriefing as the participants have full access to the data; There was iterative questioning during focus group discussions. There was also thick description of the phenomenon, context of the schools and the participants; There were presentations of aspects of the study at different stage in conferences where scrutiny from superior researchers were received; Previous research was reviewed and the findings were also linked to the previous research.
Transferability	Background data was provided and detailed information on the phenomenon that revealed the context was given.
Dependability	Three overlapping methods was employed and they were described in detail
Confirmability	Triangulation was presented in chapters 6 and 7 to reduce researcher bias, though we were all researchers. The belief and enthusiasm of participants were admitted. The shortcomings of the methods were identified, for instance it was not possible to select participants randomly all the time. Findings were represented with few diagrams and models

CHAPTER 5. SEARCH CONFERENCES

5.1. Chapter overview

This section presents the results of the qualitative analysis of the data collected from the six search conferences organised for stakeholders involved in the education of SVI in South-Western Nigeria. The research questions for this stage of the study, the aims of the conference, and the discussion of findings from the data collected, reflections on the findings and how it influenced the remaining stages in the study are discussed.

The action research (AR) design is adopted for this research as indicated in the earlier chapters, therefore the participants are considered as co-researchers. On the basis of this, six search conferences were organised in five of the six States in South-Western Nigeria. Two conferences were held in Lagos, one was for State-owned schools and the other for the Unity (Federal) schools.

The purpose of the search conferences was to jointly review the problem with the stakeholders and to seek collaboration in the research at the observation/consultation stage of the AR cycle. The procedure for the conferences was presented in the previous chapter. The problem of access to Science by the SVI was also established in the exploratory study (reported in another section of this document) in agreement with the literature, but the search conferences were organised to further confirm the observation and jointly propose ways of solving the problems in a collaborative manner. Contributions from stakeholders are important when attempting to make a change (Adebisi, Jerry, Rasaki et al., 2014)

5.2. Aims of the search conferences

It is worth noting that the focus of the search conferences was not to compare presentations between states, but to consult with stakeholders in order to confirm the situation of the problem of access to science and mathematics by the SVI from the perspectives of the stakeholders across South-Western Nigeria. The participants were informed of available resources that could be used to improve access and participation of SVI in science and mathematics during the conference. They were also invited to collaborate with the researcher to evaluate some of the resources.

5.3. Research questions

RQ3 How can the problem of access to Science by the SVI in South-Western Nigeria be solved? I looked at

- How was the problem of access to science and mathematics by the SVI viewed by the various stakeholders involved in the education of the SVI in South-Western Nigeria?
- What ways could improvements be made in collaboration with stakeholders?

5.4. Participants

Participants at each State conference included the representative of the State Commissioner for Education, the chairman of the state SUBEB, State Directors of Special Education, special teachers of SVI, Basic Science and Mathematics teachers in schools mainstreaming students with visual impairment, and sampled Students with Visual Impairment, both junior and senior secondary. It also included lecturers (teacher trainers) from the Specialist College (Federal College of Education special, Oyo) preparing TVI. The teacher trainers attended only one of the conferences for financial reasons. They attended the one that was in the same State as the College.

5.5. Findings and discussion

To begin with, it is worth mentioning that the amount of data collected from the conferences was very extensive.

This section presents the results of the qualitative analysis of the data gathered from the six search conferences organised to interact with the various stakeholders involved in the education of SVI in South-Western Nigeria. The interaction was planned in order to secure the support and collaboration of the stakeholders from the onset of the research. Each conference ended with a communiqué which is supposed to be a summary of all the presentations.

5.5.1. Categorisation and coding of the data

Before approaching the data, I considered different approaches of analysing it, seeing the huge amount of data generated. I explored methods proposed by Robson (2011 p467): the quasi-statistical, the thematic coding, and the grounded theory approaches.

I concluded that the quasi-statistical approach is not appropriate for this kind of study since the use of frequencies of keywords/words phrases for important terms may not give me the relevant information appropriate for the aims and research questions of the search conferences. However, I felt that aspects of the thematic approach and the grounded theory approach would be helpful.

Similarly considering the distinction proposed on coding by Strauss and Corbin (1998) (open coding, axial coding and selective coding) as well as Miles and Huberman's (1994) data reduction and anticipatory analysis, one might conclude that themes would eventually emerge after the steps recommended. On this note I decided to use thematic coding which Braun and Clarke (2006, p.3) considered "a poorly demarcated, rarely-acknowledged, yet widely-used qualitative analytic method within psychology which offers an accessible and theoretically-flexible approach to analysing qualitative data". Therefore, for the thematic approaches Braun and Clarke, (2006) suggested six phases which require the researcher to familiarise with/immerse in the data, generate initial code (open coding), search for themes, review the themes, define/name the themes and produce the report.

Verbal reports of stakeholders at the search conferences were considered for analysis. There was no consideration of non-verbal interaction at the conferences. At first, only the communiqué from the six conferences was studied several times before commencing an open coding. However, after a closer examination of the individual presentations at the conferences I realised some important issues raised are not included in the communiqués. I therefore uploaded and coded the group presentations in addition to the communiqués. The nodes (in NVivo, a ‘node’ is a collection of references about a specific theme) were more than thirty initially, but after scrolling through the data several times the coded data was re-contextualised and regrouped into meaningful chunks. Tesch (1990) recommended this step when analysing qualitative data. Before doing this, I revisited the research questions and aims of the search conferences, and finally mapped the coded data, created nodes broadly around salient issues raised at the conferences and recommendations of possible ways to address the problem. This, according to Anfara et al. (2002), will facilitate a story that will be understandable by the researcher and the reader. In some researches, nodes may be created before the data analysis. However, for me as an action researcher, the outcome of the action was unknown. Therefore, the nodes were developed from the data collected from the search conferences, and through iterative analysis and the constant comparative method recommended in Thomas, (2013), issues coded under some nodes were reclassified as sub-nodes. For instance, data coded under *resources* were further re-coded under *inadequacy of resources* and *lack of assistive devices*. Similarly, data coded under student’s factors were further coded as sub-node of ability of SVI, the attitude of students, career choices and the importance of independence to the SVI. Eventually, themes being constructed by the participants (including me) emerged. This is one of the unique characteristics of an interpretative approach. The themes include: a report of the problem as perceived by each group of stakeholders (which is either in agreement or disagreement with the researcher's observations), an awareness of the possibility of the SVI accessing science and mathematics, the resources available/provided in schools, students factors, the support received by SVI, teachers' factors and the time factor.

The coded data were also mapped around recommendations for teacher trainers, the National Universities Commission and the Nigerian Government.

The reported issues and recommendations are presented in subsequent sections. Each issue is discussed with sample reports from the coded references, and finally, reflections are made on the results with regard to the purpose of the search conference, clearly identifying what happens in the next stage of the AR cycle.

As a starting point, the word-count search analysis of the communiqués show, as in figure below (Tag cloud), that "Mathematics" "Students", "Science", "teachers", "teachers" and "Mathematics" have the highest count. These are the major terms of importance to this study.

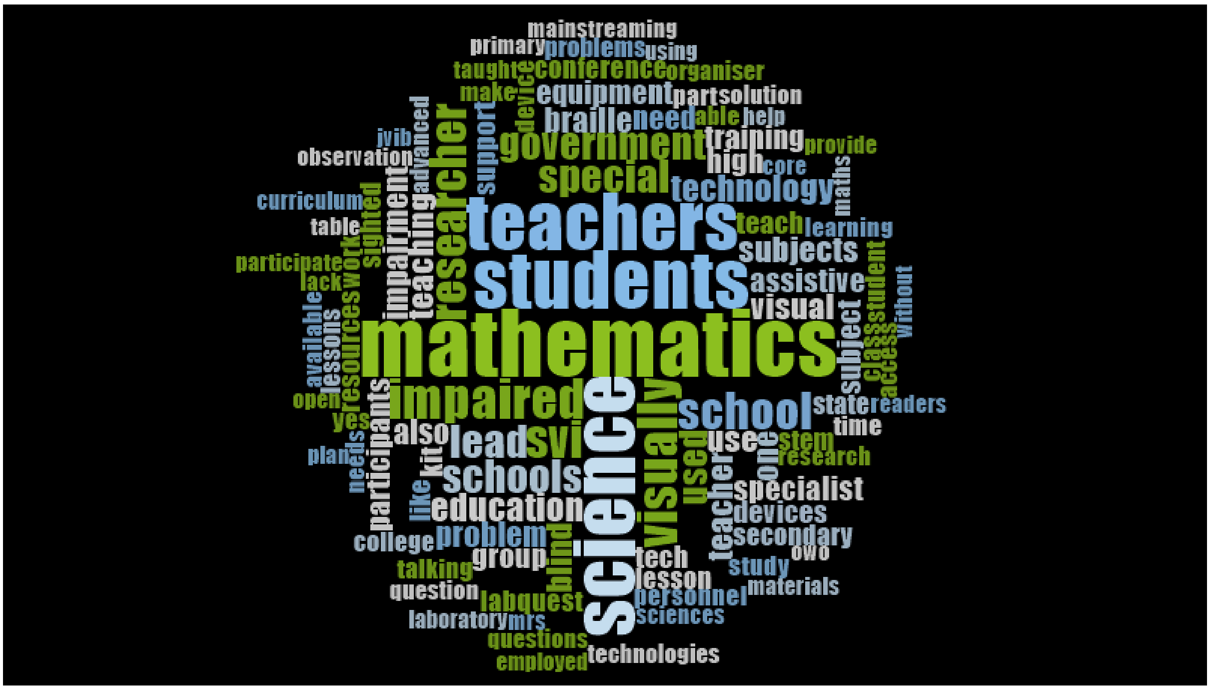


Figure 5.1: Word frequency count of the search conference presentations

5.5.2. Issues of concern

Most of the evidences reported indicate that SVI in schools have problems with science and mathematics, which is no different from the findings of my earlier studies Adelakun (1994, 2006), and the comprehensive analysis of literature recently done by Rowe (2014 p.2).

> "It has been identified that children with visual impairments (CWVI), residing in low-income environments experience a considerable deficit in the provision of teaching in the field of numeracy and mathematics, impacting on their understanding and achievement in the field of numeracy, mathematics and science more broadly" (Rowe, 2014)

One finding from the exploratory study was that some teachers were explicit that science / maths were not possible for SVI. However, it is interesting that the 'teacher attitude' seemed more positive during the search conferences, perhaps due to the mode of presentation adopted, which allowed cross-fertilisation of the ideas of all the stakeholders.

The following sections present discussions of the issues and recommendations with specific quotes from the participants.

The problem as perceived by participants

Twenty-seven references from the data reported that SVI have problems accessing science and mathematics. The references cut across all the six conferences and also across all the categories of the participants. For instance, the communiqué from E State conference reported that:

> *"The participants unanimously agreed with the organiser that there is problem accessing Science, Mathematics and parts of other subjects that include calculations and drawing."*

Similarly, junior students in E State reported that

> *"We have a problem with Mathematics and Science. The observation of the researcher is correct. We listen in Science classes; we don't offer Mathematics. There is no special teacher for mathematics."*

And the D State junior also reported that

> *"We have problems with aspects of science that involve calculations or drawings. Same for mathematics, we attend both science and mathematics lessons. We do science examinations but we do not do the mathematics examination. This confirms that we face problems in science and mathematics."*

The following are reports from the mathematics and science teachers' group across the states:

> *"It is very clear that the visually impaired have problems participating fully in science lessons. They cannot see specimens, cannot see diagrams so cannot label. They only listen in class; some of them record lessons on tape. It is amazing that they answer questions in science sometimes more than the sighted."*

> *"Observations made by the chief presenter of today's conference in person of Hajia Adelakun are right. Most of our specially challenged students in Nigeria are faced with the problem of accessing and the better understanding of science related subjects especially mathematics."*

> *"The visually impaired students have problems doing every part of mathematics and some major parts of science at the junior level. The senior students have problems in mathematics and from their experience in the junior school they don't choose to be in science or commercial class despite their yearning for career in science … they also even have problems with Biology, Agricultural Science, and Animal Husbandry offered in senior class. These students complain a lot."*

From the quotations, the SVI are reported to have problems accessing science and mathematics. They reported participation to an extent in sciences, attended lessons and took part in examinations. Their submissions purport that they only leave aspects that require drawings, practicals and calculations which are essential components of sciences. However, the report of their experience in mathematics is even worse in some schools where it is reported that they do not participate in mathematics lessons and examinations. Out of all the schools that participated in the conference, only the unity schools and E State School reported that SVI attend mathematics lessons but still do not participate in school and final examinations.

Resources

Reports on resources are discussed under two categories from twenty-eight references. There are reports on resources for teaching and those of assistive devices. It is generally reported that resources in schools are inadequate. Some said resources are in short supply or unavailable. This is evident in all the six communiqués and group presentations, for instance the reports emphasised the absence of general resources for teaching the SVI. This could mean resources to teach other subjects are also unavailable, not only in science and mathematics. For example, A and E states reported that:

> *"Resources for teaching the SVI are also inadequate or unavailable in schools."*

A particular mention was made of resources that can be felt through tactile means and those that produce sound (that can read out readings). The Mathematics teachers group reported that there is need for *"provision of special equipment & instructional material that they [SVI] can feel or touch, or can produce sound"*. In addition, the TVI group presentation in B state conference listed some resources that are particularly needed:

> *"Special equipment like talking calculators, Abacus, Taylor frames, and concrete objects must be provided".*

Apart from the general resources, seven references reported the absence of special, adapted or assistive technology devices. For example, the mathematics teachers group in D state expressed that:

> *"There are inadequate assistive devices in schools, and science cannot be taught in the abstract".*

Similarly, the junior secondary students group in A State conference expressed that the lack of proper assistive technology devices limit their participation:

> *"…our participation was limited on account of the absence of the right assistive equipment or technology".*

Reviewing all these reports from the six conferences, the important role adapted resources and assistive devices could play in solving the problem of access of SVI to science and mathematics in South-Western Nigeria is evidenced.

Student factors

Thirty-six references were reported under ability of the students and these are further coded under attitude of the students, career choices and the importance of independence to SVI. Even with the limited participation in science, the three references on the ability of SVI performing equally well or even better than the sighted are positive. The mathematics group in E state conference reported that:

> *“The special students (blind) performed well in class, sometimes more than the sighted, they need to be supported in science and mathematics”.*

Similarly, the science teachers group in A state conference reported that:

> *“SVI are known to have high intellect memory. They are sensitive to the environment which are useful skills in learning science & tech”.*

In the same vein the science teachers in the conference organised for F schools reported that:

> *“Some of them are genius, some are destined to be governors, presidents, in fact leaders but they are limited to certain career. They cannot get to their zenith”.*

Attitude of students

The reports of participants on the attitudes of SVI raised some important points. It was reported that some SVI had a phobia for mathematics and science. Such students felt science and mathematics should not be included in their curriculum. Some SVI felt persons with visual impairment should teach them these subjects if they had to do them. It was also reported that they exhibit an inferiority complex, and want to be taught separately when the sighted are not there. The need for SVI to believe in themselves and to have self-determination were also identified.

For instance, the TVI group in D conference reported:

> *"Visually impaired students should believe in themselves, and show the teachers their ability to succeed in any subjects they learn".*

And science teachers in C conference reported:

> *" …phobia for mathematics on the part of students with VI …"*

On the other hand, some reports are mixed. Some SVI as reported in F school felt that:

> *"Teachers should teach us separately", and "Science should not be included in our subjects".*

While the ministry officials (Director of Special Education), some of whom have visual impairments, reported:

> *"Inferiority complex on the part of the students and priority exchanges on the part of government."*

Career choice

Reports on career choice appeared in all the communiqués, for example E and D reported that:

> *"There should be awareness of the possibility of SVI doing mathematics and science which would allow them to pursue any course they wish after secondary education."*
>
> *"SVI should be given opportunity to study what they like and become what they aspire to be and not what the society made them to be."*
>
> *"The SVI want to be allowed to pursue their dream courses after secondary school., The idea of selecting what they can do and what they cannot do is not right."*

In addition, directors of Special Education in the ministries, and TVI who also have visual impairment reported that:

> *"They lamented that non-access to science and mathematics influenced their career choice".*

The SVI in the senior secondary also expressed similar comments and showed their happiness for the development. They consider the timing of the effort to address the access of SVI to science and mathematics to be too late for them, as they cannot study science in higher institution because their final secondary school examination is very close. For example, senior students group in D conference reported that:

> *"This development is coming up at a time that is late for us in senior class, although Senior Class 1 can benefit if they so wish, but we are happy with the development even if we cannot benefit from it due to the timing."*

Importance of independence to the SVI

There is an emphasis on the importance of independence to students with visual impairment in some of the reports. This is reflected in the reports in the communiqués. Here are some excerpts from B and A State conference:

> *"Independence performance is important to the blind".*
>
> *"They should be given opportunity to live independent life which the knowledge of Science and Mathematics would give them".*

Support

Support received during the lessons also formed a major issue, from the data gathered from the six conferences. The figure below is the result of the query on support received from the data obtained from the search conferences. A closer look suggests that the support provided for SVI in schools is inadequate. Specific mention is made of general support in their academic studies in addition to support on science and mathematics. Here are few examples:

> *"The lack of support makes visually impaired participate passively".*
>
> *"There is inadequate or no support at all in their academics".*
>
> *"Shortage of specialist personnel to support them in science and mathematics".*
>
> *"Personnel should be employed to support them in science and mathematics".*

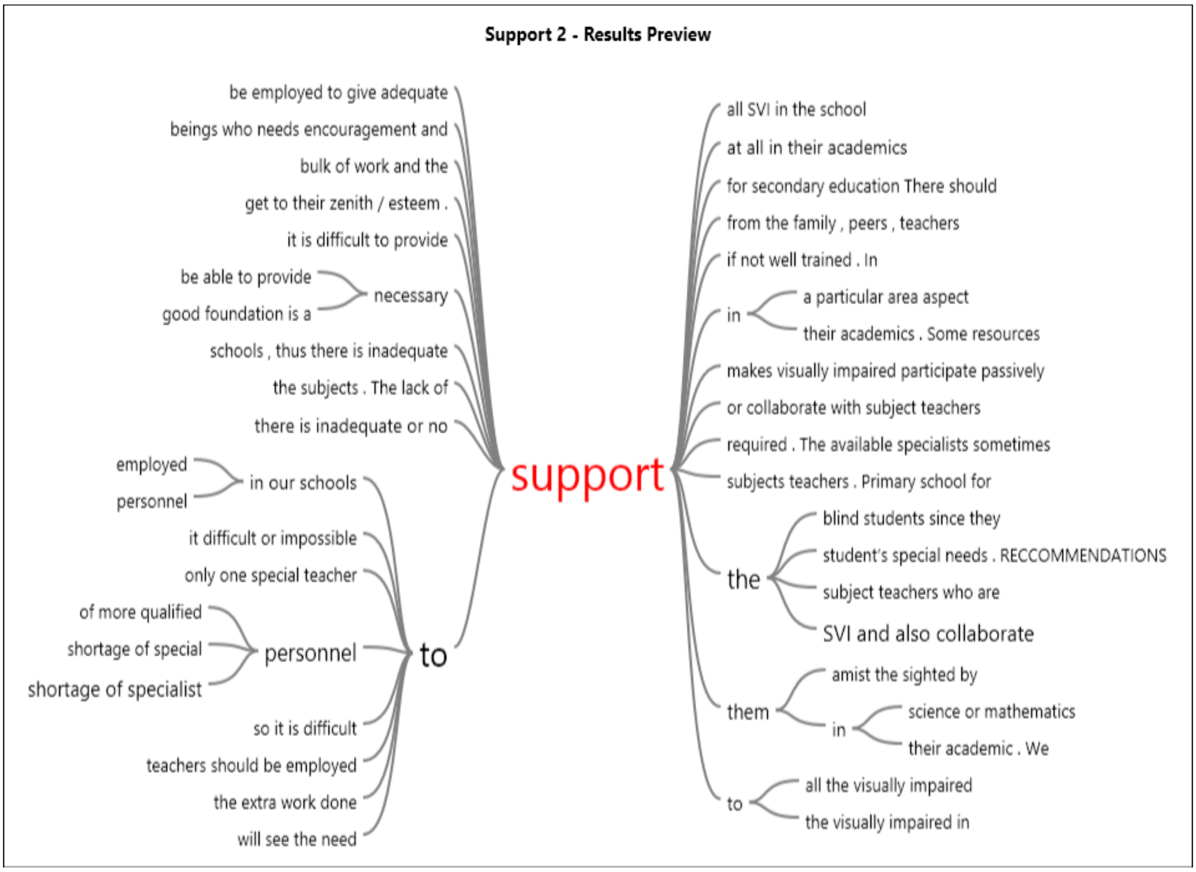


Figure 5.2: Results of the query on support received from the data obtained from the search conferences.

5.5.3. Recommendations made by the Search Conferences

For teacher training institutions

As a sign of participants' wish for solution to the problem, a number of recommendations were suggested. I coded the suggestions based on the organisations referred to in the recommendation. The first recommendations were directed to teacher training institutions. These are considered important recommendations because the training provided for their current students needs to be relevant to the requirements of the students who will be taught after graduation. The recommendations were reported in four of the six conferences and they touch on two issues: the training given to the current students in their institutions who are prospective teachers (TVI), and the need to initiate and run short term training courses (in-service) to educate TVI and interested people about the techniques and resources needed to increase participation of SVI in mathematics and science. For instance, E state reported that:

> *"Tertiary Institutions with Special Education departments should update their curriculum to include new techniques of involving SVI in Science and Mathematics. The teachers they produce will not be able to provide necessary support if not well trained."*

and A state conference reported that:

> *"Specialist teacher training colleges, and departments of Special Education in the universities should train their students with up-to-date knowledge for teaching SVI mathematics and sciences."*

The recommendations for teacher training institutions also include making available in-service training for TVI and sighted teachers already teaching in mainstream schools. It is reported in the C state communiqué that:

> *"The teacher training colleges should mount short courses to educate teachers in the field on new techniques and technologies for educating the blind on mathematics and sciences."*

For the National Universities Commission (NUC)

There was also a major recommendation that requires the attention of the National Universities Commission that is in charge of all affairs concerning Nigerian universities. This report came up in only one of the conferences, but it is a very important issue which affects the stability of professionals in the field of visual impairment. People who have studied education of SVI in the college of education are not admitted to further education in areas that could enable them to continue with visual impairment education. Many have changed their career out of frustration to management /educational technology/counselling or other courses that are different from what they studied in the college. Therefore, a lot of teachers who could teach science and or mathematics to the SVI changed career, thereby reducing the number of specialists in education of the visually impaired. This is the report from C conference communiqué:

> *"Universities and colleges should review admission criteria, such that specialist graduates from FCE Special, Oyo who wish for further training on education of the SVI, in combination with other subject areas, be admitted for their desired courses. Diversion to management /guidance and counselling/educational technology courses causes many that could teach and further research in sciences and mathematics to the blind becoming educational managers or counsellors out of admission frustration".*

The discrimination should be stopped, the universities should recognise the special nature of the Federal College of Education (Special), Oyo (it is the only one in Nigeria) by including Special Education courses in the entry requirement, such that for example, Visually Impaired education should be given recognition like other subjects (biology, chemistry, economics and others). For instance, a student who combined chemistry and education of the visually impaired should be allowed to study chemistry education at university, so that he can later impart chemistry to the SVI. Chemistry education entry requirement in the NUC brochure expect students to combine chemistry and biology or any other science subjects but not SVI education. This frustration also reduces the number of students applying to study at the Federal College of Education (Special) which is the only college of its kind in Nigeria given the responsibility of producing teachers of persons with Special Educational Needs.

For the government (D State and general)

The third set of recommendations was on issues that require the attention of the government. As discussed earlier, after familiarising myself with the data as suggested by Braun and Clarke (2006), and drawing upon the constant comparison method as suggested by Thomas (2010), twelve child nodes were created after considering the relationships of the initial nodes. Two of the recommendations are specific for D state government.

For D State Government

The first recommendation for D state concerns the establishment of a state-owned primary school for blind pupils, like in other states in Nigeria. Students with visual impairment in Nigeria (by policy provision) as mentioned in the literature are expected to attend a Special School for their primary education. This means that all this while the SVI in D state have not been adequately catered for. Here is the report from the conference communiqué:

> *“There is no government owned primary school for educating students with visual impairment in E State [pseudonym]”*

And almost all the group presentations mentioned the need for a state owned primary school for the SVI. Here are sample reports from the mathematics teachers’ group and senior secondary students respectively:

> *“We want government to establish a government owned school for the blind in E State. Almost all the states in Nigeria have schools for the blind for blind persons of primary school age. P (pseudonym) school for the blind is a private school and the blind centre in Y(pseudonym) area is for rehabilitation of adults”.*

> *“Government should establish a state school for the blind in E State to assist parents who cannot benefit from the private school that is available in the state”.*

I think this particular issue is related to the second recommendation for E state. It is reported that SVI are wrongly placed into schools. When there is no special primary school SVI are just been taken to schools without following a particular criterion. There are reports that they are not properly assessed and thus are wrongly placed in schools. Below are examples of report from D state communiqué and science teachers’ group presentation.

> *“The SVI are not properly assessed before placement. Educational planning and execution begins with assessment. The wrong placement is affecting their education”.*

Assessment procedures should be reviewed so that special needs students will be placed in designated schools.

For government (generally)

The remaining ten sub-nodes require the attention of the government and are discussed below in sequence.

Awareness

There is a need for the government to create awareness for the SVI, their teachers, parents and the public about the possibility of SVI gaining access to science and mathematics. The relationship of their participation in mathematics and science to their integration into the community should be stressed. The three quotes below focused on different points about the awareness, and they were reported by the government representatives' group (Ministry and SUBEB), the TVI and the senior secondary students' group, respectively.

> *"There is a need for awareness. The researcher should recommend relevant resources to government to be included in next allocation".*
>
> *"Awareness of the possibility of blind students studying science and mathematics should be organised by government. The students will be encouraged by the awareness and teachers will see the need to support us amidst the sighted by giving us enough attention".*
>
> *"They should be aware that it is possible for them to do mathematics and science. There should be awareness that science and mathematics knowledge is important for all to fit in successfully in the life activities".*

Recommendations on the curriculum

The issues raised on the curriculum were concerned with: the need to incorporate an adapted curriculum for the SVI into the national curriculum. In the communiqué and group presentations, there was a call for The Nigeria Education, Research and Development Council (NERDC) to provide an adapted curriculum in science and mathematics for SVI, because it would give them opportunity to participate fully in the subjects. The curriculum should also be enriched to equip blind students with useful skills which could be developed with participation in mathematics and science. Below are sample quotes:

> *" … lack of adapted curriculum for science and mathematics …"*
>
> *"The curriculum must be enriched to equip the blind students with necessary peculiar skills useful for their lives".*

The call upon the NERDC is included in this analysis despite its appearance in only one state, because the organisation plays a vital role in designing the curriculum for the Nigerian government:

> *"The Nigeria Education, Research and Development Council is called upon to adapt the curriculum on science and mathematics for the visually impaired students".*

Early introduction of mathematics and science

The importance of the early introduction of mathematics and science to SVI also emerged, and was also reported in the presentations. The science and mathematics teachers' groups and communiqué reported the vital importance of a good foundation on the performance of students. Here are sample quotes:

> *"The government should ensure that the visually impaired student be introduced to science and mathematics early enough to serve as foundation for the secondary topics"*
>
> *"Mathematics and science should be introduced from the primary school"*

Establishment of model/pilot centres

The government is called upon to establish pilot centres to serve as models for other schools, as expressed in A, C and B communiqués. Here are sample quotes:

> *"Government should establish pilot centres to serve as model for other schools".*

> *"There should be a pilot centre to serve as model for other schools".*

In-service training

Regular in-service training for sighted subject teachers on techniques of teaching science and mathematics to SVI, as well as techniques for using newly developed resources, was much emphasised. The recommendation on in-service training appeared in almost all the reports, because there is a need for training for teachers already working in schools. The recommendations are two, one for sighted teachers teaching mathematics and science and the other one for the TVI. Most subjects are taught by sighted teachers, and there is a short supply of TVI in schools. In most of the schools only one is assigned to support all the SVI in the school, who may also have visual impairment. The support needed in mathematics and science is greater than what a single non-science teacher could do. Below are sample quotes:

> *"Our subject teachers should be trained to use recently developed resources to teach us because our subjects are taught by sighted teachers who are non-specialists".*

> *"Regular training for teachers in mainstream schools, especially on technique of involving them in all aspects of the subjects we teach"*

Even the TVI recommend in-service training for sighted teachers:

> *"There is a need for training of the subject teachers, especially in science and mathematics. Training should also be extended to the specialist teachers".*

Motivation/compensation for teachers in mainstream schools

Appropriate motivation/incentives for sighted teachers in mainstream schools to compensate for the additional efforts required to involve the SVI in science and mathematics lessons appeared in all the communiqués. Some presentations also stressed that the SVI also need to be encouraged/motivated. Here are samples:

> *"Science teachers in mainstream schools should be motivated, to encourage them to put in additional effort required to teach visually impaired science".*
>
> *"Students should be highly motivated".*

Personnel

A query on the word 'personnel' from the communiqué of the six conferences is shown in figure below:

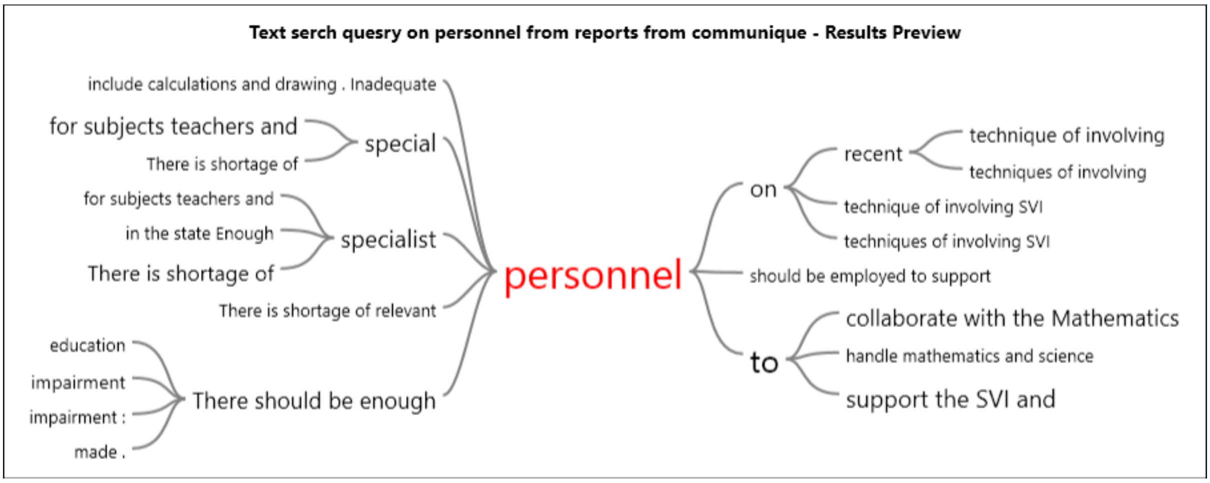


Figure 5.3: Query on the word 'personnel' from the communiqué of the six conferences

Great emphasis was placed on lack of specialist personnel, and the need for the government to employ more specialist personnel (TVI) to support all the teachers especially in science and mathematics. The idea of having a single TVI in schools is condemned, as well as a single TVI doubling as student counsellor.

Physical planning

There were a few references to the need for the government to improve the environment in the mainstream schools to be inclusive so that SVI could move freely within and outside the classroom.

> *“Physical planning in schools mainstreaming SVI should be repaired with inclusive facilities”.*

Procurement of necessary resources

Procurement of necessary resources appeared in all communiqués and group presentations. This is likely due to the important role of the equipment/resources that are designed for teaching mathematics and science to SVI. The government is implored to buy necessary resources, including the ones presented by the researcher, so that schools give the SVI opportunity to the choose careers they so desired, which will likely enhance their independence. Here are some excerpts:

> *“ … provision of necessary resources that can be used to teach science and mathematics to visually impaired”.*

> *“The government should procure necessary equipment to make us able to participate in science and mathematics”.*

Separate supervision board

Effective supervision should be put in place, and B State proposed having a Special Educational Needs (SEN) Board, to ensure adequate provision, and also to enhance adequate supervision for mainstream schools. The need for the constitution of a separate supervision board for SEN affairs appeared only in B

State's report. I considered it important because it took me quite some time and effort to get consent for the B state conference, because the affairs of the staff, school and students are under different organs of government. Below is an example of the quote from the B State communiqué:

> *"There is need for a Special Education Board to oversee affairs of the specially challenged people including the SVI in the state".*
>
> *"Needs for special schools are under the ministry and teachers of secondary schools are under TESCOM. This is not good. B state needs a board for Special Education. This will make the government give adequate attention to Special Education issues".*

5.6. Reflections on the findings

The purpose of the search conferences was to consult with stakeholders on the problem of access to mathematics and science by the SVI, and to jointly collaborate to propose a change. With the various group presentations, the perspectives of the participants on the problem emerged. Reflecting on the communiqués and group presentations, there is much emphasis on the lack of necessary resources that can be used to enable access to mathematics and science by the SVI, especially by sighted teachers, and there is a shortage of specialist personnel. This suggests that resources that can be physically touched by the SVI, and accessible to the sighted teachers, might improve access of mathematics and science to the SVI. Provision of such resources that could bring improvement/solution to the problem was also identified. Reflecting on these findings led me to the procurement of the Talking LabQuest for improving SVI participation in science/laboratory activities. The design of the STEM kit came after realising that Talking LabQuest could not be used to involve SVI in drawings and hands-on calculations, especially where they are taught by sighted teachers in a mainstream setting. Both Talking LabQuest and the STEM kit were used for intervention. The description of the design and procurement were described earlier, in Chapter 4.

Shortage of specialist personnel was also a major concern, as discussed earlier. Sometimes the specialist personnel double as the counsellor, and may also have visual impairments. All these limit the type of support that such can provide for SVI during mathematics and science. This is a pointer to the need for resources that can make the sighted teacher able to effectively teach the SVI along with the sighted.

The readiness of sighted teachers to do so was also reflected in their recognition of the ability of SVI, and their expression of the fact that despite their limited participation in sciences, they sometimes answer questions correctly more than their sighted classmates.

The student participants emphasised the effect of the inaccessibility of Mathematics and Science on them and called for solutions to the problem. They displayed a readiness to learn how to use the resources, and appealed to the Nigerian government to provide the necessary resources and training for their teachers.

From the search conferences' results, there was substantial evidence in confirmation of the fact that the SVI access only a very small part of the science and mathematics curriculum. The practical aspects, and any drawing or calculation, are left undone. Therefore, it is important to introduce Talking LabQuest that can be used by SVI and their sighted classmates in a science activity/laboratory lesson, and the STEM kit which can be used individually by each SVI like notebooks to sighted students. The unique feature of having both print that can be seen by sighted teachers, and the braille equivalent that can be felt by SVI simultaneously, might improve their access to mathematics and sciences.

These reflections on the findings of the conferences form the basis for the next step in my action research cycle.

CHAPTER 6. ANALYSES AND DISCUSSIONS OF FINDINGS IN STUDY SCHOOL1

6.1. Chapter overview

This chapter analyses, presents, and discusses the findings of the action research in the study school 1. . The chapter is divided into three parts. Part one includes findings, and discussion of data from observations of classroom teaching. to obtain different stakeholder views (or multiple realities as described by Bogdan and Biklen 1982), part two includes a broad presentation of findings from the stakeholders (participants); from the e-mail interviews with teachers; and from focus group discussions with SVI and sighted classmates.

The third part presents triangulation of data from the three data collection methods used. The aim is to identify similarities and differences in the findings, and relate the findings to previous research presented in the literature review. This was achieved through several de-contextualizations of the findings into 'meaningful chunks' as suggested by Tesch (1990). The presentations and discussions are supported with excerpts from the data, and these are shown in italics.

The aim of the research was to evaluate the impact of the TLQ and the special STEM kit on the participation, engagement and independence of the SVI in science and mathematics lessons. The key focuses of the study are**:** to the STEM curriculum, engagement in class activities and independence of learning generally.

6.2. Analysis and discussion of observation data (initial and final)

This section presents the overview of the observation of participants during classroom lessons and laboratory activities, before and after the intervention with the Talking LabQuest and the STEM kit. All observations recorded for each SVI are summarised in a table**.** Some background information, to give the context/situation of the participants, was also included, such as the technology in use by SVI before using the resources. Observation of the independent performance of task and the support received by SVI during the lesson was compared with their sighted classmates. How the SVI used the resources and coped with the progress and delivery of the lessons, and how the use of each of the resources affected the sighted classmates and the accomplishment of tasks, were also recorded. Ten tasks, rated over 10 (see Appendix Vai and ii) were altogether given as classwork with STEM kit and TLQ. The tasks consisted of specific instructions on the classwork (calculations and graphs plotted) with STEM Kit, and processes taken in turn during the practical class with TLQ.

A short commentary on the table in respect of the key focuses of the intervention earlier mentioned is provided for each participant. A general summary of the key findings of the observations is also provided at the end of this section. These will be further considered under triangulation in the latter part of this chapter.

It is important to remember that the Talking LabQuest was used mainly for laboratory activities (data collection in the laboratory or field (science/ activities), while the STEM kit was used for subjects or topics that require graphing, calculations and drawings (hands-on activities).

6.2.1. Analysis of observation data

Initial observations, summaries of findings of the observations with the resources, analyses of the data obtained when STEM Kit was used, and when TLQ was used are presented in the following tables 6.1 – 6.20. Below appears the initial observation of Wale during mathematics and basic science lessons, followed by a summary of the observations during these lessons while using the resources. The same presentation is shown for Segun, Lekan, Tinu and Sade below, in that order

Table 6.1: Overview of the initial observation of Wale during mathematics and science lessons

Items	**Initial observations (without the STEM kit)**	**Initial observations (without the Talking LabQuest)**
Subject/ Topic	Mathematics: Factorisation.	Basic science: Solutions and Solubility
Engagement	Sat down in class and listened, did not present previous homework.	Sat in the class on the edge of the laboratory table.
Participation	Sometimes he did other things during the lesson. There was a time he was weaving a cap with thread while the lesson was on. Did not do classwork and did not take down homework given by the teacher.	No active participation during any activities; only listened to teacher's voice.
Support received	No support from TVI or teacher.	None
Accomplishment of tasks	Nil.	Nil

Table 6.2: Summary of the findings of observation of Wale during Science and Mathematics lessons

Technology in use by Wale before the intervention	**Mobile phones, tape recorder, computer, abacus**
Independent performance of tasks	Located his seat independently in the class and freely moved around the school without sighted assistance with the aid of the mobility cane. He did 9 of the 10 listed tasks in Appendix Va on his own to the acceptable level explained in Chapter 4. (He did at least 3 steps in each question on his own).
Support	Support received on the task by Wale was similar with the sighted, except that the teacher supported him by aligning steps in some task. The teacher explained examples to him directly with the Kit like he did for sighted on the chalkboard.
Braille textbook	No braille textbook for science and mathematics
Use of resources	Wale arranged the figures (tiles) in ascending order on the top right side of the metallic board and the operational signs on the lower right below the figures during all classroom activities by himself. He also used the TLQ efficiently followed the steps in Appendix Va closely.
Progress and method of delivery	The teacher wrote on the chalkboard and read out approximately 60% of what he wrote. The pace was okay for Wale as he was able to finish some tasks faster than some sighted peers in the class for example, when he labelled the 'x'-axis during mathematics lesson. Wale also submitted his graph sheets after solving the questions but each time he raised a hand to invite the teacher to see the axes before starting another, because the tiles will remove once the graph sheet is lifted from the metal board. He also needed to re-use the tiles. The teacher said the plotted points were enough to assess the graph.
Effect of the use of STEM kit during lessons on sighted classmates	During the first lesson with the STEM kit, the majority of the students in the classroom focused attention on the three SVI in the class. The sighted student that sat to the right of Wale offered to assist him but Wale politely rejected such when arranging the tiles on the metallic board but during subsequent lessons they focused on their work. The teacher's attention, too, was more on the SVI during the first lesson with STEM kit but later he was able to share his attention more evenly.
Effect of the use of talking LabQuest during lessons on sighted classmates	The students worked in groups because it was a laboratory lesson. They handled the LabQuest in turns, and Wale was the first to measure temperature and pH each time in his group. The sighted students recorded the readings inside their notebooks. Wale also recorded with slate and stylus after the lab work, and typed his readings with a typewriter and submitted them to the class teacher. He hasn't been trained to analyse and print readings with the TLQ.
Accomplishment of task	From the three lessons observed with the STEM Kit he accomplished 9 of 10 tasks correctly, and got Question 3 wrong because of the minus sign. He added, instead of subtracting 3 from 6. Measured temperature and pH successfully with TLQ with confidence, except that the items were gathered and supplied to him.

Observations when the STEM kit and TLQ were used are summarised below in separate tables.

Table 6.3: Overview of the findings on engagement, participation, support received/ independence and accomplishment of tasks in overall observation of Wale working with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/ Topic	Mathematics: Factorisation, Quadratic graphs.
Engagement	He set at least three steps in each of Questions 1 – 6. He was immersed in the work, was either picking or returning tiles from the beginning of each task listed in Appendix Va.
Participation	He plotted his graph using adapted graph sheet, tiles, plasticine and joined the plotted spots with wikki stix. Got the tasks right but spent more time than the sighted.
Support received	Received guidance from the teacher on one task apart from the general individualised attention / teaching given to each of the SVI when explaining examples before the classwork. He was supported with STEM kit.
Accomplishment of tasks	Accomplished 9 out of 10 tasks correctly.

Table 6.4: Overview of the Findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Wale working with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/ Topic	Basic science: Determination of temperature and pH of three liquids
Engagement	Held and operated the Talking LabQuest in his group and pressed the data collection button each time. He requested from his groupmate 'I want to measure the temperature before all of you' and he followed all the steps correctly.
Participation	Waved hands to locate the conical flask containing the liquids after the first reading. Touched the flask, dipped the temperature probe and quickly pressed the data collection button. Released the LabQuest to his sighted mate in the group and listened as the readings were voiced.
Support received	Received support from the laboratory attendant. They set the conical flasks and other things in the work tray before starting, and the sighted classmates placed materials back in his own working tray so it was easy for him to locate them.
Accomplishment of tasks	Got results, operated the LabQuest and was involved. Recorded the results on the LabQuest. He followed all the required steps in Appendix Va.

Table 6.5: Overview of the initial observation of Segun during mathematics and science lessons

Items	Initial observation (without the Talking LabQuest)	Initial observation (without the STEM kit)
Subject/Topic	Basic science: Solutions and Solubility.	Mathematics: Factorisation.
Engagement	Sat on the stool at edge of the table.	Sat down in the class listening, did not do class work but was weaving with thread under his desk, or sometimes putting his head on the table when his sighted classmates started solving class work given by the teacher.
Participation	No participation.	Sometimes he did other things during the lesson; did not do classwork and did not take down homework given by the teacher.
Support received	None.	No support from TVI or teacher.
Accomplishment of tasks	Nil.	Nil

Table 6.6: Summary of the findings of observation of Segun during Science and Mathematics lessons

Technology in use by SVI before	**Mobile phones, tape recorder, and computer**
Independent performance of tasks	Located his seat independently in the classroom, but needed sighted assistance to move round wider areas in the school. Used mobility cane to move between classes. He was assisted on all the tasks but the assistance was reduced on Questions 7 and 10.
Support	Support received by Segun was more than that of the sighted and the other SVI, but it reduced during subsequent lessons. He was assisted by the sighted to arrange up to half of the tiles during the first lesson, and was able to arrange the tiles himself by the third lesson. With TLQ, his hand was guided to the tip of the conical flask each time by his group classmates.
Braille textbook	No braille textbook for science and mathematics
Use of resources	Segun struggled with arrangement of the tiles all the time, but there was improvement as he got used to it. He was unable to save his readings when temperature was measured but saved the readings when pH was measured.
Progress and method of delivery	The teacher wrote on the chalkboard and read out approximately 60% of what he wrote. Segun spent a longer time to form the table of readings, plotting the graph also took him more time. Most of the time, teachers had given others new instructions before Segun finished last instruction. He was also slower using the TLQ because he didn't want to make mistakes. Though slower than others he got some right.
Effect of the use of STEM kit during lessons on sighted classmates	During the first lesson with the STEM kit, the majority of the students in the classroom focused attention on the three students in the class. The sighted students that sat to the left and right of Segun assisted him when arranging the tiles on the metallic board, but during subsequent lessons they focused on their work. The teacher's attention too was more on the SVI during the first lesson with STEM kit, but later he was able to share his attention more evenly. Kept the three SVI in the front after the first lesson.
Effect of the use of talking LabQuest during lessons on sighted classmates	The students worked in groups because these were laboratory lessons. They handled the LabQuest in turn, and Segun was the second to do that. The Sighted students recorded the readings inside their notebooks. Segun recorded with slate and stylus from the saved readings on the TLQ after the class with which he typed out the report submitted to the sighted teacher.
Accomplishment of tasks	From the three lessons observed, Segun accomplished 6 of 10 tasks almost independently, and the rest with support from sighted classmates and teacher.

Below appears the initial observation of Segun during mathematics and basic science lessons, followed by a summary of the observations of Segun during these lessons while using the resources. The same presentation is shown for Lekan, Tinu and Sade below, in that order

Table 6.7: Overview of the findings on engagement, participation, support received/independence and accomplishment of tasks in overall observation of Segun with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/Topic	Mathematics: Factorisation, Quadratic graphs
Engagement	He was engaged from the beginning of the task. He was, most of the time, busy arranging the tiles on the metal board and he raised his hands to invite the teacher to check his work. He tried hard during all the questions, even the ones that he got wrong.
Participation	He was excited because he factorised and got Question 2 right. He plotted his graph using adapted graph sheet, tiles, plasticine and joined the plotted spots with wikki stix and sometimes with thread or broom stick.
Support received	Received support from the teachers on almost all the tasks except Question 2. He was supported when using STEM kit. The teacher taught him individually with STEM Kit.
Accomplishment of tasks	Accomplished 6 out of 10 tasks without much help. Some help required aligning tiles on the metallic board, but got Questions 3, 6 and part of laboratory measurement wrong.

Table 6.8: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of <u>Segun</u> with TLQ

Items	Observation during lessons with Talking LabQuest
Subject/Topic	Basic science: Determination of temperature and pH of three liquids.
Engagement	Allowed his sighted peers to measure temperature of the first liquid, as he was unable to measure using the TLQ during the first laboratory work, but he was seen operating the TLQ. He measured the PH of the liquids and also recorded the data in subsequent laboratory.
Participation	Worked with peers in his group, they took turn and was either holding the LabQuest or removing or inserting the sensor or probe in the liquids or listening attentively as the readings were voiced.
Support received	Received support from the sighted classmates. They collected all items needed by the group, and guided his hands to the conical flask containing liquids all the time.
Accomplishment of tasks	Collected data with the LabQuest when it was his turn, and was involved in the experiment but not as quick as the sighted. He missed Step ii in Questions 7 and 8, and thus he could not measure the temperature, but avoided the mistake in another laboratory lesson and was able to measure the pH within allowed time.

Table 6.9: Initial observation of Lekan during science and mathematics lessons

Items	Initial observation (without the Talking LabQuest)	Initial observation (without the STEM kit)
Subject/Topic	Basic science: Solutions and Solubility.	Mathematics: Factorisation.
Engagement	Sat in the class on the edge of the table with Wale.	Listened to the teacher’s explanations, did not do class work and did not submit previous homework which sighted classmates submitted, but sometimes put his head on the table when the sighted classmates were solving class work given by the teacher. Took permission to the toilet in one of the lessons.
Participation	No participation in the activities just sat on his seat because it is an offence to be out of the classroom during lessons.	Sometimes he did other things during the lesson; there was a time he was weaving a cap with thread while lesson was on. Did not do classwork and did not take down homework given by the teacher.
Support received	None.	No support from TVI or teacher
Accomplishment of tasks	Nil.	Nil

Table 6.10: Summary of the findings of observation of Lekan during science and mathematics lessons

Technology in use by SVI before	**Mobile phones, Tape recorder, computer, abacus**
Independent performance of tasks	Located his seat independently in the class and freely moved around the school, without sighted assistance but with the aid of the mobility cane. Sometimes requested sighted aid when going to senior school. Tried all the tasks on his own but was supported by the teacher and sometimes by his group classmates during laboratory work. The support was mostly in aligning the tiles to differentiate steps.
Support	Support received by Lekan was initially much on the first three questions. He was aided in returning tiles after use by the sighted to his right and the one in front of him but he caught up quickly and worked independently on the remaining tasks.
Braille textbook	No braille textbook for science and mathematics
Use of resources	Lekan readily arranged the types all the time it was used by himself after the first lesson with STEM kit.
Progress and method of delivery	The teacher wrote on the chalkboard and read out approximately 60% of what he wrote. The pace was okay for Lekan as he was most of the time able to work on the tasks like his sighted peers, aside from time spent returning tiles after completing each task, and when his hand was guided to the conical flask.
Effect of the use of STEM kit during lessons on sighted classmates	During the first lesson with the STEM kit, the majority of the students in the classroom focused attention on the three students in the class. The sighted that sat to the right and front of Lekan offered to assist him several times, but he politely rejected except on two occasions such as when arranging the tiles on the metallic board during the first lesson with STEM Kit. During subsequent lessons they focused more on their work. The teacher's attention too was more on the SVI during the first lesson with STEM kit but later he was able to share his attention more evenly
Effect of the use of talking LabQuest during lessons on sighted classmates	The students worked in groups because they were laboratory lessons. They handled the LabQuest in turn and Lekan held the LabQuest, followed required steps and pressed the collection button each time he used it. Sighted students recorded the readings inside their notebooks. Lekan also recorded with slate and stylus or sometimes he recapped recordings on the TLQ after the lesson.
Accomplishment of task	From the three lessons observed, Lekan accomplished 7 of 10 tasks correctly and the rest were wrong in a few steps.

Table 6.11: Overview of the findings on engagement, participation support received, independence and accomplishment of asks in overall observation of Lekan with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/Topic	Mathematics: Factorisation, Quadratic graphs
Engagement	He was engaged from the beginning of the task till the end of the class. He arranged the tiles such that figures 1 to 5 were top right of the metallic board, and figures 6 to 9 and 0 were arranged at the lower left of the metallic board. The operational signs were placed by the top left. He was busy arranging the type on the metal board as he needed. Plotted graph with the adapted graph sheets. Submitted his graph sheets without the tiles.
Participation	He was excited, solved questions dictated by the teacher and got most of the questions right. He plotted his graph using adapted graph sheet, tiles, plasticine and joined the plotted spots with wikki stix, Showed the teacher his class work each time before starting another question.
Support received	Received support fully from the teacher on one task. He was supported with STEM kit.
Accomplishment of tasks	Accomplished task 1, 2, 4, 5 and 6 correctly with STEM Kit, tried question 3 but got it wrong missed the minus sign.

Table 6.12: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks on overall observation of Lekan with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/Topic	Basic science: Determination of temperature and pH of three liquids.
Engagement	Allowed the sighted classmates to measure temperature of the first liquid, he measured the temperature of the second liquid and pH of the first liquid. Each time he operated the talking LabQuest and saved the data.
Participation	Lekan led his group in the first activity when measuring the temperature and they worked in turns. He was active throughout the activities. Requested his peers to be silent so that he could follow the readings. He made sure the data was saved so that he could have access to the readings after the class since he could not copy in a note or braille and still follow the activities.
Support received	The sighted peers helped to assemble all the materials to be used for the laboratory activities on the work tray. The teacher also explained the procedure for measuring the pH to him when he asked.
Accomplishment of tasks	Followed the steps as in Appendix Va, collected data with the LabQuest and was involved in the experiment throughout.

Results of observations of the senior students is also presented in a similar form. Their experiment measured temperature and pH of liquids but it was different from what the junior students did. The senior students (1) measured the heat of the solution generated when salt was dissolved in water during one of the laboratory sessions, and (2) they also measured the pH of two liquids separately, and then poured one into the other gently. They noted that the pH changed after mixing. In their mathematics, the topic treated was Motion and they solved problems relating to Kinetic and Potential energy.

The observations of Tinu and Sade are also presented below:

Table 6.13: Overview of initial observation for Tinu during mathematics and science lessons

Items	**Initial observations (without the Talking LabQuest)**	**Initial observations (without the STEM kit)**
Subject/Topic	Chemistry: Periodic table, Simple equations	Mathematics: Algebra: Equations
Engagement	He was not in the science class during initial observation but he took an active part in Biology, which is a science subject offered by Arts students. He answered questions well but could not draw diagrams drawn on the whiteboard.	Listened to the teachers' explanations, did not do class work and did not submit previous homework which sighted classmates submitted. However, he followed the lessons and sometimes asked questions.
Participation	No participation in the activities just sat on his seat because it was an offence to be out of the classroom during lessons.	Tinu followed closely what the teacher taught, but sometimes put his head on the table especially when the teacher pointed to the whiteboard and asked them to copy what was on the board or referring them to see the board. Tinu did not do classwork and did not take down homework given by the teacher.
Support received	None.	No support from TVI or teacher.
Accomplishment of tasks	Nil.	Nil

Table 6.14: Summary of the findings of observation of Tinu during Science and Mathematics lessons

Technology in use by SVI before	**Mobile phones, tape recorder, computer, magnifiers**
Independent performance of tasks	Tinu reads braille although he has some useful vision (tunnel) which is too limited for his study but he moved freely in the classroom and laboratories. Located his seat independently and freely moved around the school without sighted assistance. Tinu arranged the tiles on his own and followed the steps in the laboratory activities.
Support	Tinu did not receive support any different from the sighted peers. He used his remaining vision and magnifier and worked independently.
Braille textbook	No braille textbook for science and mathematics
Use of resources	Tinu readily arranged the tiles all the time but brought them close to his eyes each time, using his remaining vision to view the prints on the tiles, but sometimes he used his magnifier.
Progress and method of delivery	The chemistry teacher wrote on the chalkboard and read out approximately 50-70% of what she wrote. The pace was okay for Tinu as he was able to work on the tasks like the sighted peers.
Effect of the use of STEM kit during lessons on sighted classmates	The students focused on their work and were not distracted in the class when Tinu used the STEM kit. The teacher's attention was more on the SVI during the first lesson with STEM kit but later she distributed her attention fairly to cover the entire students.
Effect of the use of talking LabQuest during lessons on sighted classmates	Tinu was in group 2 with four other sighted classmates during laboratory work. Tinu led his group in the experiment twice. Initially it was strange to the students, but as time went on they got used to it. They took readings down in their notebook and also stored the readings on the LabQuest so that they could be accessed after the lesson. Tinu really understood how to use the LabQuest more than anyone in the group, from the training conducted by Cary.
Accomplishment of tasks	From the Mathematics lessons observed, Tinu accomplished 9 of 10 tasks independently and the rest with support from the teacher. He also took a leading position in the practical within his group.

Table 6.15: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Tinu with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/Topic	Mathematics: Motion: Calculating Potential and Kinetic Energy
Engagement	Tinu used the STEM kit to do his calculations. He used the formula $K=½MV^2$ to solve Questions 2, 3 and 6, and P=mgh to solve Questions 4 and 5. He was engaged with the task till the end of the class. He sometimes used his remaining vision to identify the tiles, bringing them very close to his eyes in a particular direction. He also used the TLQ to measure temperature and pH of solutions.
Participation	Tinu was happy, listened carefully to the questions dictated by the teacher. He got most of the questions right because he was given credit for getting through the rest of the process correctly, even if his final answer turned out wrong. He did the first two steps in the questions and was asked to move to another question. He also interacted well with the group classmates.
Support received	Received support from the teachers and the sighted peers on all the tasks. He was supported when using the STEM kit. He omitted some steps in Questions 7 and 9 but eventually got the answer.
Accomplishment of tasks	Accomplished 7 out of 10 tasks with little help, and the remaining 3 with much help from the teacher. Initially was using PE formula for Question 6, but when the teacher checked his work, he quickly changed the formula.

Table 6.16: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Tinu with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/Topic	Chemistry Practical: Determination of Heat of solutions and PH of three liquids
Engagement	Tinu worked with other four students in the group. He held the talking LabQuest firmly, and fixed the temperature probe while one of the group classmates poured the salt into the liquid. Tinu dipped the other end of the probe in the solution and stirred. His group classmates took their turns and finished up the task before other groups. He worked with other sets of students for the other experiments and he was very active, since he understood the function of the LabQuest better than all the other students.
Participation	Tinu participated actively in all the activities, each time supporting himself with his residual vision to support his learning.
Support received	The teacher supported him during calculations of PE and KE, especially when he was interpreting Question 2 and when he was arriving at the units of Step ii in Questions 2 to 6. He wasn't supported when using the LabQuest.
Accomplishment of tasks	He assembled materials used together with his sighted peers. Did his own experiment when it was his turn, though mixed up the steps but got the temperature and the pH values. He measured the liquid with the notched syringe.

As for Sade, the fifth SVI participant in study school 1, she had some understanding of mathematics from her primary school. She had attended a private primary school where she was introduced to mathematics (addition, subtraction, multiplication) with an abacus.

Table 6.17: Overview of initial observation for Sade during mathematics and science lessons

Items	**Initial observations (without the Talking LabQuest)**	**Initial observations (without the STEM kit)**
Subject/ Topic	Chemistry: Periodic table, Simple equations	Mathematics: Algebra Equation
Engagement	She was not in the science class during initial observation. She told the counsellor when she joined the school five months before this research that she would prefer to be in science classes, but was counselled that she would have problems with science subjects. Sade also had problems with drawings in Biology.	Listened to the teacher's explanations, did not do mathematics classwork and did not submit previous homework which sighted classmates submitted. However, she followed the lesson and sometimes asked questions. Asked teacher to explain at times.
Participation	No participation in mathematics activities. She just sat on her seat sometimes dozed off during the lessons.	Sade was attentive when the teacher gave an explanation on the topic. The teacher sometimes asked the class to copy what was on the board. Sade did not do classwork and did not take down homework given by the teacher.
Support received		No support from TVI or teacher.
Accomplishment of tasks	Nil	Nil

Table 6.18: Summary of the findings of observation of Sade during Science and Mathematics lessons

Technology in use by SVI before	**Mobile phones, tape recorder, computer, abacus, talking wrist watch**
Independent performance of tasks	Located her seat independently in the class and moved around the school with sighted assistance and or with the mobility cane. Sade was able to calculate final answer to Questions 2 and 3 on her own. She arranged the tiles figures 0, 1 to 9 in ascending order on the right side of the metallic board and the operational signs on the left side.
Support	Support received by Sade during the lessons was more than that of the sighted students. The teacher checked her more than the sighted. But she independently filled the tiles and arranged her work with minimal correction.
Braille textbook	No braille textbook for science and mathematics
Use of resources	Sade readily arranged the tiles all the time. She had a problem measuring water with the notched syringe so she was assisted by her group classmates. She was also helped to pour salt into the liquids, but she stirred and took the readings by herself.
Progress and method of delivery	The teachers wrote on the whiteboard and read out approximately 50-70% of what she wrote. The pace was okay for Sade as she was able to finish the task faster than some sighted classmates in the class in mathematics, but was helped to align lines differentiating steps.
Effect of the use of STEM kit during lessons on sighted classmates	During the first lesson with the STEM kit, sighted students in the same row with Sade and the teacher focused attention on her. Sade politely rejected help from students close to her when they offered to assist her. The teacher's attention was fairly distributed to cover the entire students as the kit became more familiar.
Effect of the use of talking LabQuest during lessons on sighted classmates	The students worked in groups because it was a laboratory lesson. They handled the LabQuest in turn, and Sade was the first to operate it. Sighted students recorded the readings inside their notebooks. Sade also saved on the LabQuest and would braille the reading with slate and stylus/Perkins Brailler after the lessons. She was helped by sighted peers on few steps in question 7 to 10.
Accomplishment of task	From the three lessons observed, she accomplished 9 of 10 tasks correct with different levels of independence and got Question 1 wrong even with support. However, the teacher helped to align the steps sometimes.

Table 6.19: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of <u>Sade</u> with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/ Topic	Mathematics: Motion: Calculating Potential and Kinetic Energy
Engagement	She used the STEM kit to execute her calculations. She solved problems related to Kinetic Energy $K=½MV^2$ and Potential Energy P=mgh. She could not get P in her kit and the teacher asked her to use any other letter. She was engaged with the task till the end of the class.
Participation	Sade was excited, looked for tiles and formed the equation and the other steps on the metallic board. She was happy when the teacher told her “you got it”.
Support received	Received support from the teachers and group classmates on Questions 7 to 10. She was supported when using the STEM kit straightening the rows. The teacher supported her during Calculations of PE and KE, especially when she used PE instead of KE formula.
Accomplish-ment of tasks	Accomplished 9 tasks correctly; got one wrong.

Table 6.20: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Sade with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/Topic	Chemistry Practical: Determination of Heat of solutions and pH of three liquids
Engagement	Sade worked with other four students in the group and with another set of students during the second experiment. She fixed the temperature probe to the talking LabQuest and allowed her sighted classmates to start while she listened to the reading at first. She held the Talking LabQuest, requested a new solution and salts. She poured the salt, carefully guiding the open end of the conical flask, inserted the probe in the solution and started stirring. She pressed the data collection button and continued stirring until the temperature started reducing. Her group lab mates recorded their readings inside their laboratory notes. They also repeated the experiment, but saved the readings because Sade would need them after class. Sade did her experiment twice because the salt spilled during her first attempt, so her peers helped her to pour the salt and even measured the water.
Participation	Sade participated actively in all the activities. She asked the teacher to repeat dictation of the questions several times during mathematics lessons when she did not get the question or when she needed to start another question, because there were no braille Mathematics or Chemistry textbooks.
Support received	The teacher supported her during calculations of PE and KE, especially when she used PE instead of KE formula. The teacher also helped her when pouring salt into the conical flasks, measuring water with notched syringe and pouring liquids into liquids to get the final pH. However, she took all her readings by herself.
Accomplishment of tasks	She took the readings independently when supplied with all the materials needed aside from the measurement mentioned earlier. She collaborated well with her sighted classmates.

6.2.2. Discussion of the findings from observations

The discussion is presented in relation to the key focuses of the observations mentioned earlier, which were: access to the STEM curriculum; engagement in class activities; and independence / independence of learning.

Access to the STEM Curriculum

The findings presented in the above tables suggest that with the resources (STEM Kit and the TLQ) the SVI had access to the science and mathematics curriculum taught by sighted teachers in the mainstream classroom. From the above presentations, Sade and Tinu could calculate kinetic energy and potential energy during mathematics lesson with the STEM Kit. Wale, Lekan and Segun also calculated and solved questions on factorisation and simple equations with the STEM Kit. All the five SVI participants also participated in laboratory experiments; they measured temperature and pH with TLQ in the laboratory in groups with sighted peers. This is in agreement with Sahin and Yorek (2009 p.20) that “visually impaired students can learn anything and achieve the same success as their sighted peers do”, and as reported by Kumar, and Stefanich (2001), visually impaired students have the same range of cognitive abilities as sighted students. Jones, Minogue, Oppewal, Cook and Broadwell (2006) believe that they can master higher-order science concepts just like the sighted if adequate and appropriate accommodation is made by the teacher/school.

The tables also reflect that the lessons were taught by sighted teachers who were non-specialists and had never attended Special Education training, despite having taught in the mainstream school for at least six years. As mentioned in the literature review, Norman, Caseau and Stefanich (1998) in a survey of American teachers, report that over half of teachers (elementary to University) have received no training specific to teaching disabled students. Similarly, Fraser and Maguvhe (2008) report that many teachers have only had general teacher training; he maintains that they lack skills and ideas for adapting the curriculum. This suggests that it is not peculiar to Nigeria, therefore this study, in agreement with previous research, recommends inclusion of meaningful Special Education knowledge in the general education curriculum in teacher training courses/institutions.

Engagement in classroom activities

Unlike before, it is reflected in the findings presented in Table 6.3 and Table 6.4 that Wale was engaged in activities with STEM Kit and was fully involved in group activities when TLQ was used in the laboratory, sometimes even faster than his sighted classmates. There was also evidence that he took almost half the time to accomplish some tasks when compared with the sighted students. The teachers supported Wale, and they were still able to teach the whole class. Dunn and Meredith (2004) express that with a little ingenuity and willingness to learn, disabled students can be included in a wide variety of learning situations. Similarly, Sade "*fixed the temperature probe to the talking LabQuest and allowed her sighted groupmate to start while she listened to the reading at first. She held the Talking LabQuest, requested a new solution and salts. She poured the salt carefully, guiding the open end of the conical flask, inserted the probe in the solution and started stirring".* The same is true for Lekan and Segun. It is the contrast with before the resources were available to them and as a result/impact of the action involved in the action research.

Independence / independence of learning generally

Independence is very valuable to SVI, as shown in the literature; the students have a varying level of independent movement within the school compound. Tinu moved independently within the classroom and the school compound using his remaining vision. Wale and Lekan moved independently within the classroom and school compound with the mobility cane, while Sade and Segun required sighted assistance: Sade possibly because it was her first year in the school, while Segun had an additional disability. This suggests that they received necessary support from their TVI on orientation and mobility training. Researchers have broken orientation and mobility down into eight components, and emphasised that all the components are important, and lead to increasingly independent travel, and confidence and competence that will be useful in other aspects of life and also extend beyond school years (Fazzi and Naimy, 2010; Fazzi and Pettersmeyer, 2001). These components are: body concepts, environmental concepts, spatial concepts, perceptual and sensory skills, mobility skills, orientation skills, interpersonal skills and decision-making skills (Fazzi, 2014).

Furthermore, accomplishment of tasks and support received are also related to independence. As reflected in the tables, all the five SVI were able to perform tasks given by the teachers during lessons successfully, although with various degrees of independence. Wale, Tinu and Sade scored 9, Lekan scored 7 and Segun scored 6 out of 10 in tasks given by the teachers. Their scores were comparable with their sighted classmates. Their level of independence in the class activities can also be compared with that of their peers. The findings are in agreement with a small scale qualitative study of Sahin and Yorek (2009) who report: “Blind students showed that they could actually perform many of the activities in experiments, such as plotting graphs, measuring angles, classification of rocks and minerals, and solving mathematical problems” (p. 21). Similarly, Cryer and Gunn (2008) report the importance of learners being equipped with the right skills. The level of ECC skills possessed by the SVI could be attributed to their success in the tasks, but more in-depth study is needed that will measure the ECC, to directly identify its relationship with the performance of SVI in science and mathematics. However, Sheppard and Aldrich (2001) report that teachers highlighted that tactile graphics help pupils to think in different ways.

In conclusion, the SVI were able to access the same curriculum, comparably with their sighted classmates. They were engaged in activities when the resources were used unlike before, and were still comparable with the sighted peers. The support received from the teacher seems more than given to the sighted, but it was not enough to prevent achievement of the aims of the mainstream lessons.

The next section presents an analysis of the email interviews (with science and mathematics teachers), and the focus group interview (with SVI and sighted classmates) in study school 1. The findings have been presented together to be able to compare the reports from the different stakeholders that were involved in the study. The chapter also includes a broader triangulation of findings from the three methods. Finally, a summary of the implications of the study for study school 1 is presented.

6.2.3. Analysis and discussion of findings from stakeholders through e-mail interviews and focus group discussions

The findings from the stakeholders (teachers, sighted students and the SVI) are presented and analysed together in this section. A brief cross-analysis with what was observed was also included under this section.

All the five teachers sent responses to my e-mail, as explained in the methodology chapter. The information was copied from the e-mail and pasted into the interview source document created in NVivo. Each was labelled with names which are pseudonyms, and was also given an identification number to be able to differentiate them as shown in Chapter 4.

Similarly, transcripts of separate focus group discussions with the SVI and sampled sighted classmates were also uploaded into the focus group source document in NVivo (see the methodology chapter for the procedure).

Both email interviews and focus group discussions were organised as follow up to the observations, to find out if the TLQ and the STEM kit had been beneficial to the SVI, whether they had an impact on the learning of the sighted classmates, and whether they had an impact on the ECC skills possessed by the SVI.

The findings were coded in NVivo under similar themes, and through manual analysis the strength of the discussions was also identified between the group members, considering the following questions: *Were there disagreements? Or did they reach consensus on issues? Were there shared understandings? Was there any influence on the ECC competency of the SVI?*

Some keyword searches derived from the research questions were queried and the findings were presented and discussed under each theme separately for STEM Kit and TLQ. The discussions of findings were supported with excerpts from the data and these are italicised.

The following themes eventually emerged from the analysis of the interview and focus groups data and are discussed separately for STEM Kit and TLQ:

1. Usefulness of the resources (STEM kit and TLQ).
2. Weaknesses/suggestions for improvement of the resources.
3. Influence of the resources on independence/engagement of the SVI.
4. The perceived effect of the resources on their sighted classmates.
5. Impact of the resources on understanding of the lessons by SVI.
6. The perceived change in ECC competency of the SVI.
7. Dynamics/strength/characteristics of the discussions.

Usefulness of the resources

STEM Kit: Reports from the teachers in study school 1 included fifteen references from five sources on the teachers' assessment of the STEM kit. All the four subject teachers reported that the STEM kit was found very useful for the SVI, because it gave them the opportunity to teach SVI what was impossible when it was not used. They expressed their happiness on what they were able to do with the STEM kit. For example, CS101 Mathematics teacher reported that "*The resource got me and the students (SVI and sighted) happy as all of us were involved in the learning process*". Similarly, the science teacher CS102 reported that “*The special students really feel included in the lessons. We did not have the opportunity before*”.

The TVI CS105 in the school also related her experience with the tools and what the SVI related to her, whenever the teacher used STEM kit to teach them in class. According to her, she used the resources herself and the students also related to her that they found the resources very useful. “*The SVI improved a lot in their participation during the Basic Science lessons when the STEM kit was used. This is indeed surprising. They were also elated; they told me stories of what they learnt in the class almost every time the kit was used*”. “*The kits are very important for both experiment and theoretical works*”. The STEM Kit was found to be useful, as reflected from the study of Davis and Hopwood (2001 p. 6) that “teaching materials usually require adaptation to meet the needs of the child” and that “effective teaching methods in an inclusive classroom involve multi-sensory access to the curriculum”. With the STEM Kit the sense of touch on the part of the student can be combined with the visual sense of the teacher in the delivery of the lessons.

In addition, many benefits of the resources were also identified during the focus group discussions with the SVI; some were specific for STEM Kit or TLQ and some were expressed referring to both. Generally, the SVI participants reported that both resources were useful for them. For instance, regarding the STEM Kit, the following were expressed:

> *“I didn’t understand it at all when it was taught without STEM kit” [VI2]*
>
> *“It is very easy because someone can read the letters on the tiles by feeling it” [VI2]*

> *"The difference is that, it makes it very easy, it increases my knowledge, if we did not do it practically, I wouldn't have understood the topic". [VI1]*

Furthermore, the sighted classmates listed a number of useful aspects of the special STEM Kit and the TLQ, which were even used together with SVI during laboratory activities. Some examples are:

> *"It helps them to be able to do what was impossible for them before" [S1].*
>
> *"It is used to arrange things that the sighted write in their exercise book" [S3 and S4].*
>
> *"It works like the sighted pen and exercise book used by the sighted" [S2].*

Comparing the lessons with and without the STEM Kit, some of the sighted classmates said:

> *"What they did with the STEM kit was better in the class...They won't be able to do it on their own, but with the help of the kit they were able to do it". [S4].*
>
> *"Most of the special students are not able to view what they are teaching them....they will just be listening........so it helps them to see /feel what the teacher is teaching" [S1].*

In addition to the usefulness, the teachers raised the specific strength of the STEM Kit in eleven references from three sources. The opportunity for the sighted teacher to be able to teach the SVI with the kit appears repeatedly, and is presented in different forms. Providing and enhancing opportunity for teachers to understand the SVI more and reducing the problems encountered by the teacher are other strengths mentioned. Some excerpts are here presented:

> *"The STEM kit seems to me a very intellectually constructed resource. This is because, before now, teaching science and Mathematics to the SVI is a herculean task" [CS104].*
>
> *"It reduced the difficulty associated with teaching my subject (Mathematics) by making it a real, and not an abstract course, to the SVI" [CS 104].*

"The strength is the ability of the teacher (sighted) to understand the SVI better which wasn't possible before" [CS101].

"The strengths of the resource are its application to and enhancement of a better teaching and learning experience for both the teachers of SVI and SVI students" [CS102].

From these reports it can be concluded that the participants liked the STEM Kit, because it gave them access to the curriculum and it enabled them to engage in classroom activities like their sighted peers **(**Cryer 2013). This is also similar to what was observed that was presented earlier.

Talking LabQuest (TLQ): All the teachers, including the TVI, reported that they found the Talking LabQuest very useful for taking readings in science activities and experiments. Even the TVI (who is blind herself) who studied on a non-science course in the college reported that she tried measuring temperature and pH of some solutions. She was motivated to try the experiment by the pressure, stories and explanations of the students who were taught with the resources. She tried it when the basic science teacher was trial testing the resources before teaching the students. It was also reported that they were happy at being able to participate fully in the lessons. Here are some excerpts in relation to usefulness of the TLQ:

"It is a very useful one as it helps the visually impaired to do so many practical works which were almost impossible without the resources". "I did it without any constraint despite that I am blind. The students also came to tell me they had great experience they never thought is possible". [CS105]

Some teachers also reported that:

“It was a breakthrough experience for me, allowing me to have a high level of confidence in teaching Chemistry to the Visually Impaired”. [CS103]

“I had an illuminating experience using these tools as it was something soothing that a visually impaired teacher like me can understand what is done in the laboratory. Most especially the visually impaired students were able to follow what the teacher teaches in mathematics”. [CS105]

"A brilliant experience because I was able to use the talking LabQuest to determine temperature and pH of solutions when the teacher was preparing to teach Basic Science to all students both SVI and Sighted. It enhanced the understanding of the SVI and didn’t reduce that of the sighted”. [CS105]

“Even Segun that always complains of lessons became more active and will be asking if the teacher will teach them with the resources every morning”[CS105]

The SVI participants also expressed that the TLQ was also very useful. It enabled them to participate and engage with practicals, which was impossible before. For instance, it was unanimously agreed during SVI focus group discussions that TLQ is very useful for SVI in laboratory work. Various uses were identified and are here shown:

“It was used to take readings during experiment. To tell us readings we *cannot see”. [VI1]*

Specifically,

“When the pellet of sodium hydroxide dissolves and the temperature rises. It helps me to understand more because I have never imagined that” [VI4]

Similarly, the sighted classmates expressed that TLQ helped them, for example:

“It helps me to understand more than when it was not used” [S1]

Overall, the three stakeholders (the teachers, SVI and the sighted peers) established that the two resources are useful not only to the SVI, but actually benefited the sighted classmates and made the teachers happier with the work they do.

And finally, seven references from four sources were expressed on the strength of the TLQ. The comments revolved round the expressions of happiness by SVI and the improvement in teaching and learning experiences.

> *“It has in no way detracted teachers from teaching.”*
>
> *“The strengths of the resources are that they enhance better teaching and learning experience for both the teachers of SVI and SVI students” [CS102]*
>
> *“A very useful one; it helps the visually impaired to do so many practical works which were almost impossible without the resource” [CS103]*

In summary, the students and teachers liked the resources; they were motivated because the students enjoyed improved access to the subjects, better engagement during the lessons activities and equity. They were able to work like their sighted classmates, which was different from what they were used to. The opinions of the stakeholders were the same with the observed findings.

Weaknesses of the resources

The weaknesses of the resources in terms of what they found not suitable for them and or what they have as suggestions for improvement were expressed by the three stakeholders.

STEM Kit: A major weakness mentioned was that the kit did not have facility for SVI to save a solved piece of work for review at a later time. The tiles were also always disorganised when a new question was to be answered, due to the limited work surface, and the limited number of tiles supplied with each kit. The effort of SVI returning used tiles before starting another one wasted time.

One of the SVI noted that STEM Kit can become useless if the tiles got missing but other members in the group disagreed with this opinion, and advanced that the magnetic property of the tiles would prevent their loss, and that the tiles are supplied in multiple numbers. The producer will also make extra type available for purchase, so we should not consider that as a weakness of the kit. *["I think each tile is more than one". "The magnetic feature of the tiles will make losing it hard*". "*The seller would also sell extra tiles"].[VI1]*

Another weakness identified is about the type of braille adopted, a participant felt "the braille on the tiles are upgraded braille", because the STEM Kit is prepared with newly adopted UEB (Unified English Braille), which is officially adopted in Nigeria, but not yet adopted in some schools. However, the remaining SVI participants felt they were coping with the braille type, and requested to be trained on the differences in the UEB and the English Braille they are currently using.

TLQ: Weaknesses of the TLQ as reported have to do with the speed and speech: some students complained that it was too fast and they found it difficult to hear the readings being read out. Distraction of the teachers during teaching was another weakness of TLQ. However, the distraction occurred only during the first use as presented in the observation data. Finally, the speed and loudness of the speech of the TLQ are identified as a weakness by the SVI in the junior school, but those in the senior school considered these appropriate.

The weaknesses identified for both resources are specific areas to improve which are also easy to solve. The quantity of each tiles supplied with the STEM Kit can be increased, while the producer of the TLQ can work on the recording and possibly tailor specific ones for use in specific parts of the world. The speech and speed of the TLQ should be understood by all students.

The perceived effect of the resources on the sighted classmates

The effect of the resources on sighted classmates is coded as *positive, negative* or *undecided.* It is considered *undecided* if the teacher is silent about the point. The teacher reported that the sighted classmates felt positive towards the resources; for instance, CS104 expressed that "*The sentiment the sighted have for SVI made them become happy for the SVI as they (SVI) were better involved in the class" "The resource was seen by the sighted as a succour for their SVI peers*". That is, the sighted classmates were happy for the visually impaired students as they thought the materials were helpful to their classmates with visual impairment.

Specifically, Olowo CS102 expressed that "*The STEM kit affected the sighted students' engagement positively as there was no reason for any distraction for them".*

All the five references coded reported that STEM Kit had a positive effect on the sighted classmates.

TLQ: All the teacher respondents also reported that the TLQ had positive effect on the sighted classmates. Kate CS105 expressed that:

> *"The sighted had more time to finish up their practical activities since it is mostly done in groups with the SVI. They have more time*

> *for themselves during the practical thus improving their work as well".*

The SVI engaged more with the apparatus, and took turns on activities, unlike before when they used to be passive listeners during laboratory activities**.** This portrays a good social interaction between SVI and sighted classmates, despite the wide gap in their ages. The happiness and excitement displayed by the sighted peers can be associated with opportunity to use new equipment for measuring temperature and pH instead of the usual mercury bulb thermometer used for measuring temperature, and litmus paper or pH scale. It is also different from some classes in the USA, and maybe the UK, where the equipment is naturally supplied to all the students, and voiced TLQ would just be an accessible format of what the others are using. Even when students have individual apparatus, group experiments are often conducted everywhere in the world in science laboratories, due to other valid reasons, such as the need to develop better team working and interpersonal skills needed in employment after schooling (Stone, 2014). Similarly, when the sighted classmates were asked if the resources affected their understanding, there was a chorus answer that it affected them and there was a positive response from one participant that *"It helps me to understand more than when it was not used".* This was not argued by other members. There was no negative comment on special STEM Kit and the TLQ. This is similar to the findings of Sahin and Yorek (2009). Since science teaching heavily depends on visual instruction, both visually impaired and sighted students may have difficulty in constructing abstract concepts, therefore they need mostly tactile and more hands-on experiences to learn science, like the ones provided by STEM Kit and the TLQ. It was also observed, as presented earlier, that students that worked in groups without a SVI partner tried to swap groups to have opportunity to use the TLQ.

Influence of the resources on independence

Some reports indicated that the resources supported and improved independence of SVI in classroom activities as well as in laboratory work. These are discussed separately for STEM Kit and TLQ.

STEM Kit: The impact of the resources on students' engagement in activities and independent performance of tasks was also coded**.** As identified in the literature that independent performance of tasks is very valuable to SVI. Olowo, CS102, noted improved independent performance of tasks and practicals by her students when the STEM kit was used. She expressed that:

> *"I had an exposing experience using these tools as I have never imagined having opportunity of fulfilling my aim of having my SVI pupils to be able to do STEM independently".*

And also, Kate CS105 wrote "*Its strengths include the ability of the SVI to work individually with the resources*".

In addition, when SVI were asked how the special STEM kit functionality affects their understanding, they said:

> *"It enabled us to participate in the class".[VI1]*
>
> *"It is very easy because someone can read the letters on the tiles by feeling it" [VI2]*

Further to this the sighted classmates also expressed that with the STEM Kit:

“They were able to focus on the [study] and even when they make mistake they will be corrected”. “It helps them to be able to do what was impossible for them before”. [S14]

TLQ: The TLQ was also said to support individual performance of practical in the following excerpts:

“The LabQuest enhances some individuality or some unassisted practical works by the Visually Impaired” [CS103].

“The talking LabQuest is a very useful resource for scientific experiment; making the SVI pupils have a high level of independence and confidence while doing the experiments” [CS102].

The sighted also commented on the engagement of SVI with classroom activities. They reported that SVI enjoyed different aspects of the lessons when they engaged in activities as reflected in these excerpts:

“The one I enjoyed most was when they were [checking] the temperature. When they put the NaOH in the solution and the temperature rises” [S11].

“talking LabQuest can be used to do a lot that will make science and mathematics easier for SVI” [S12].

The perceived change in ECC competency of the SVI

The change in ECC competency was apparent from various reports of the teachers, the SVI and their sighted classmates. These touch different aspects of ECC. For instance, there was evidence from the teachers’ responses that students were more engaged with resources. McNear and Farrenkopf (2014) suggest an improvement in use of assistive technology as reflected in this excerpt:

“The talking LabQuest is a very useful resource for scientific experiment; making the SVI pupils have a high level of … and confidence while doing the experiments”. [CS102]

This suggests an improvement in self-determination (Wolffe and Rosenblum, 2014). Some reports from the teachers about successful participation of students in group experiments have to do with having developed and exhibited good social interaction, because group experiment involves taking turns and other forms of cooperation with group members. This is in consonance with the following nine components listed from the research of experts in the field of blindness and visual impairment (Sacks and Wolffe, 2006; Sacks, Wolffe and Tierney, 1998).

1. Appropriate body language
2. Social communication
3. Effective conversation patterns
4. Cooperative skills
5. Interactions with others
6. Social etiquette
7. Development of relationships and friendships
8. Knowledge of self
9. Interpretation and monitoring of social behaviour.

The findings from focus group discussions with students suggest that there were changes in the following aspects of ECC: self-determination, assistive technology use, sensory efficiency, and social interaction. It is worthy of note that these skills overlap with each other (Sacks, 2014). According to Wolffe and Rosenblum (2014), the definitive tool for assessing self-determination in SVI has not yet been developed, however informal assessment has been adopted. Self-determination was exhibited by SVI’s choice of what they wanted and needed. That occurred several times during the lessons, which was quite different from what they did when the resources were not used. It was also assessed with the checklist, as discussed under methodology. Assistive technology refers to knowledge and skills that are essential to learning how to use technology McNear and Farrenkopf (2014). This knowledge, according to them, does not exclude SVI because the role of AT is very important to the lives of SVI. It is recommended that an AT assessment be done by a team of people in the life of SVI, both in the school and at home. The checklist was used to informally assess the AT skills of the SVI before and after the intervention, and it was realised that they improved in the use of all the resources. Sensory efficiency overlaps with AT, because the STEM Kit requires a level of tactile skills and the TLQ requires hearing skills. Social interaction of the SVI greatly improved with the use of the resources. The group work with TLQ and support received after class with STEM Kit showed an increase in their social interactions. Despite the wide gap in the ages of SVI, they felt free and interacted well with the sighted classmates.

Dynamics / strength / characteristics of the discussions

This is considered in terms of: the relationship between the group members and the agreement/disagreement between members. Did they reach consensus on issues? Was there shared understanding? And was there any influence on the ECC competency of the SVI?

The SVI displayed positive social skills which are an aspect of ECC. There were disagreements on two issues, (possibility of loss tiles and the speech of the TLQ), but they eventually reached consensus on the issues once the other members explained why they disagreed. They shared similar understandings of the functionality of the two resources; they were able to use the resources. They achieved competency; thus it could be said to have improved their ECC competency in the aspect of use of assistive devices and also social interaction within the group.

As discussed in respect of SVI pointed out earlier, the strength of the discussion was also not very strong although there were agreements on the usefulness of the resources, engagement and participation of the SVI in activities. They reached a consensus that SVI prefer lessons taught with the resources than the ones taught without them. There was no disagreement among them.

6.3. Triangulation of data

Triangulation, as used in this study, involves cross-analysing the findings from three methods of data collection which is referred to as ‘methodological triangulation’ by Patton (2002) or ‘between-method’ triangulation by Bryman (2012). The advantages and disadvantages of each method used were highlighted in Chapter 4. Triangulation of the findings is necessary to enhance confidence in the findings of the study and to address limitations associated with each method (Denzin, 1970; Webb et al., 1966; Webb, 1996; and confirmed by other researchers, Patton, (2002). Bryman (2012) suggested that the uncertainty of interpretation of findings could be greatly reduced by confirming the propositions by two or more independent measurements. The reasons for, and benefits and process of triangulation in this study have been fully presented in Chapter 4.

Pulling together findings from the observations, e-mail interviews and focus group discussions was not easy. However, it was easier having presented the findings from stakeholders in the last section. This section compares findings of the e-mail and focus group discussions earlier presented. The convergence or divergence of findings from the three methods are here presented.

Cross-analysing findings of the three methods

The essence of triangulation lies in cross-analysing the findings from the three methods (Sabina and Rahman, 2012), in order to identify areas of agreement and disagreement. The summative themes were obtained from decontextualization and cross-analysing of findings from the three methods. and It served as a guide for the discussion of similarities or divergence in the findings. In all, there were no disagreements in the findings from the three methods. The major difference was in the amount and characteristics of information collected with each method. As explained in Chapter 4, and corroborated with the presentations in the tables 6.1-6.20, the data collected with the semi-structured observation schedule was more detailed. It captured the nuances, facial expressions and excitement and other non-spoken details that are not reflected or cannot be captured with in the email interview or focus group discussions. For instance, observation data indicated that SVI were seen arranging tiles on the metallic board and raising their hands to invite the teacher to check their work. Laboratory attendants supplied each group with what they needed for the experiment, and the teacher explained the procedure and allowed SVI to explore the apparatus before starting the experiments which are not captured with interview and focus groups.

Similarly, difficulties that were not reported by the teachers, SVI or sighted classmates were identified. For example, none of the stakeholders mentioned the difficulty or stress involved in replacing the tiles before starting another question. It also took SVI extra time, which constituted a little setback for them.

Furthermore, on observed was that the sighted classmates gained more time to do the classwork, since it took the SVI a little more time to finish some tasks. This was from observation data, it was noted that the teacher gave explanations regarding the activity or experiment each time before the experiment. The processes involved in experiments were also explained to all the students, unlike during initial observations. The level of independence and engagement with resources were detailed in observation data. Data on weakness of the resources were also detailed in observation and briefly mentioned during focus group.

Finally, the implications of major findings of AR in study school 1 were also discussed.

6.4. Implications of the findings for study school 1

As a summary, the SVI in study school 1 found the resources useful, since these give them access to the science and mathematics curriculum and support their engagement and independence with lessons and laboratory activities. The findings have some implications for individual SVI, the science and mathematics teachers, the heads of the schools, and the government of the state where study school 1 1 is located. The implications are discussed below:

6.4.1. For the individual SVI

It is worth nothing that the network of roads within the school was reflected in the O & M possessed by the SVI, as they are confident in many activities. They should improve on this and other ECC skills by practising more with the resources. They should also show determination to follow their choice of career. It is also important that they learn and be proficient in UEB with which the STEM Kit was designed. They should practice with the research assistant such that teachers could continue to teach them what sighted are taught in mainstream classes with less stress and disadvantage to the sighted classmates.

Reports reaching me from the school show that teachers were using the resources, SVI are more confident and the principal is particularly contacting the state government to provide the resources He has also requested for training of the staff in the school. The stakeholders collaborate in the registration of the NGO to sustain the change achieved during the study.

6.4.2. For the science and mathematics teachers

Another implication for study school 1 has to do with regular training of the staff of the school about visual impairment, and what is expected of teachers in mainstream schools that will enable access of the curriculum to all students. Specific training is needed for the science and mathematics teachers. The TVI in the school also need to be trained to support teachers, such that high expectations will be set for SVI in all the subjects**.**

6.4.3. For the head of study school 1

The environment and facilities in study school 1 is more inclusive and the effects show in the ECC skills developed and displayed by SVI. However, the government needs to increase the number of TVI. A sighted TVI will be able to give support in material adaptations for subjects like science and mathematics

In terms of material, each student should have a pack of the STEM Kit, and the school should have a few quantities of TLQ to accommodate the SVI in laboratory science. The level of facilities in the school suggest that the state government could provide these resources and can arrange for future training for the teachers in the school.

The general provision of adequate science laboratories made introduction of the resources possible without much stress. This is very encouraging. Similarly, the computer and IT provision available in the school was also good, however these facilities did not have the SVI in mind. Therefore, it is recommended that assistive software like JAWS should be installed on all the computer systems for both the junior and senior secondary sections of the school. This will allow the SVI to use the computer to submit assignments, or even do examinations for sighted teachers, instead of using typewriters or requesting the TVI to convert braille answers to print for sighted teachers. They could also analyse the saved data on the TLQ, and send the graph to the printer to get their work ready at the same time as their sighted peers.

The broader implication of the “what next” which consolidates the purpose of the study, the design adopted (AR), linked with the critical paradigm which focuses on emancipation of the SVI from the situation of denial of their educational rights is further discussed in Chapter 8.

CHAPTER 7. ANALYSES AND DISCUSSIONS OF FINDINGS IN STUDY SCHOOL 2

7.1. Chapter overview

Like Chapter 6, this chapter presents, analyses and discusses the findings of the action research in study school 2 ('Amos Grammar School'). This chapter is also divided into three parts, following a similar structure as in the previous chapter (study school 1 1). Part one includes findings and discussions of data from classroom observations of science and mathematics teachings. Part two includes a presentation of the findings from email interviews conducted with staff, and focus group discussions with SVI and sighted peers. The triangulation of findings from observations and the stakeholders' reports are presented in Part three, in order to identify the similarities and differences in what was observed and the reports from the teachers and students. The presentations and discussions are supported with excerpts from the data and these are shown in italics. The chapter concludes with the implications of the study for .

The purpose of the study was the same as with study school 1: to give me an opportunity to evaluate the resources in a different and contrasting context, in terms of facilities and the practice of inclusion. This will enhance robust recommendations for future educational practice in schools involved in the research.

7.2. Analysis and Discussion of Observation Data (initial and final) in study school 2

In this section, the presentation is different from that of Chapter 6 because of the different context of the school. Therefore, the findings from initial observations of science lessons for all the SVI in study school 2 are presented in Table 7.1, because these students were not attending mathematics lessons. All the observations recorded for each participant when the resources were used are then summarised and presented in separate tables. Some background context and parameters used for answering RQ4 are also included in the table. A short summary is presented after the presentation of the analysis.

7.2.1. Analysis of the observed data

In study school 2, the STEM Kit was used during mathematics lessons in Junior Secondary School One (JSS1) and TLQ was used during science activities in JSS3. The task given to the SVI in study school 2 are different (see Appendix Vb) from that of study school 1 because the context of the school and participants was different. Therefore, the final observation is shown in Tables 7.2 – 7.9 for each of the SVI in JSS3 and Tables 7.10 – 7.15 for SVI in JSS1.

Table 7.1: Summary of the findings of initial observation of all SVI during science/mathematics lessons in study school 2

<table>
<tr><th rowspan="2">Participant's ID</th><th colspan="2">Initial observations</th></tr>
<tr><th>Engagement/Independent performance of tasks</th><th>Support received, resources in use</th></tr>
<tr><td>1) Opeyemi
JSS3
(TLQ used
during science lessons)</td><td>Sat on his seat with slate and stylus. brailled some information, but stopped when the teacher gave classwork on the chalkboard to sighted classmates to solve. He asked questions sometimes from the teacher. Moved with sighted assistance within and outside the classroom all the time.</td><td rowspan="6">Received no support from the teacher, the TVI was not in their classroom.

Have no Braille textbooks. No special resources were used by the teacher during the lessons observed.

Sighted students had printed mathematics and science textbooks</td></tr>
<tr><td>2) Jadesola
JSS3
(TLQ used
during science lessons)</td><td>Came to class in the middle of the first initial observation with a sighted friend. Only listened to the teacher's explanations. Asked questions once throughout the three initial observations. Needed sighted assistant to move within the classroom and within the school compound.</td></tr>
<tr><td>3) Maryam
JSS3
(TLQ used
during science lessons)</td><td>Had slate and stylus, but seldom used it in class, always sat and listened to teacher's explanations. Rested her head on the table sometimes. Always moved within the school and within the classroom with a sighted guide. Classroom setup was not consistent.</td></tr>
<tr><td>4) Jolade
JSS3
(TLQ used
during science lessons)</td><td>Had passive participation in the lesson. Asked questions in class and teachers also asked her questions, but did not participate in science activities. Moved within the classroom and the school premises with sighted aid.</td></tr>
<tr><td>5) Joseph
JSS1
(STEM Kit used during Mathematics lessons)</td><td>Had some limited vision but only moved within the classroom. Supported by a sighted friend within the school premises. He read braille because his vision was only for recognising big obstacles on the way.</td></tr>
<tr><td>6) Ade
JSS1
(STEM Kit used during Mathematics lessons)</td><td>Did not attend mathematics lessons. Moved within and outside the classroom with sighted friends.</td></tr>
<tr><td>7) Adediran
JSS1
(STEM Kit used during Mathematics lessons)</td><td>He was led all the time by a sighted friend. Was not in the classroom during mathematics</td><td></td></tr>
</table>

Table 7.2: Summary of the findings of observation of Opeyemi during science lessons taught with TLQ

Technology in use by SVI before	Mobile phones, tape recorder, computer
Independent performance of tasks	Opeyemi was the first to measure either temperature or pH of liquids in his group. The teacher explained the procedure to be followed in the experiment at the beginning of each activity and this helped SVI who cannot read the instructions on the chalkboard. Opeyemi asked questions about the steps when confused.
Support	He independently performed the tasks. Politely refused help or support offered by sighted classmates. He was guided by the teacher initially. The TVI was in the laboratory during the practical activities with TLQ.
Braille textbook	No braille textbook for science
Use of resources	He handled the resources properly. No spilling of liquid during the activities.
Progress and method of delivery	The pace was okay for the visually impaired as the teacher moved round the group to answer questions and illustrated what he drew/wrote on the board for SVI.
Effect of the use of Talking LabQuest during lessons on sighted classmates	Opeyemi worked with three sighted students and four sighted students in two different laboratory tasks. He handled the LabQuest and operated it while others recorded the readings in their notebooks as they listened attentively to the voice coming from the TLQ. Sighted peers also saw the readings on the screen of the TLQ. He also had his turn and listened when others had theirs.
Accomplishment of tasks	Independently Opeyemi accomplished the four experiments successfully. He operated the TLQ for measuring pH and temperature. Stored the data for later use since he was unable to take down data with slate and stylus and still participate in the experiment.

Table 7.3: Overview of the findings on engagement, participation, support received, independence and accomplishment of task in overall observations of Opeyemi working with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/ Topic	Basic science: Determination of temperature and pH of two liquids
Engagement	Held and operated the talking LabQuest in his group first before others, and had complete control of equipment when it was his turn. He measured the temperature of liquids in conical flask A and B followed the steps as required.
Participation	Waved hands to locate the conical flask containing the second liquid after the first reading. Touched the flask, dipped the temperature probe and quickly pressed the data collection button. Released the LabQuest to his sighted classmates in the group and listened as the readings were voiced.
Support received	Received support from the sighted peers. They set the conical flasks and other things on the table before starting as there were no work trays. The TVI supported by ensuring the required lab wares are provided and stayed throughout the lab activities, which was not the case before the intervention. SVI received support from their classmates and the TVI in contrast with lack of support received before the intervention.
Accomplishment of tasks	Operated the LabQuest and was involved. Recorded the result on the LabQuest when it was his turn. He accomplished all the four experiments.

Table 7.4: Summary of the findings of observation of Jadesola during science lessons taught with TLQ

Technology in use by SVI before	Mobile phones, MP3, computer, abacus.
Independent performance of tasks	Jadesola was seen operating the TLQ, listened as the readings were voiced, waved her right hand to find the second conical flask and her hand was guided to the conical flask each time she waved her hands.
Support	She received support from the teacher and friends during the first measurement but worked independently afterwards. She missed some steps in the first experiment but followed the steps in the remaining three experiments. Since there was no tray to serve as work space, sighted classmates guided her hands to the direction of lab wares. The TVI was in the laboratory and also ensured that the students were supplied all the required apparatus.
Braille textbook	No braille textbook for science
Use of resources	Jadesola initially was shaking to handle the TLQ but later handled it with confidence by the second time.
Progress and method of delivery	The pace was okay for the visually impaired since experiment was individually done within the group. The TLQ determined time spent on the measurement.
Effect of the use of Talking LabQuest during lessons on sighted classmates	Jadesola with four other sighted classmates worked together in a group during laboratory work. Initially it was strange to the sighted students, but as time went on they got used to it. They took readings down in their notebooks and it was also stored on the LabQuest. They all listened to the readings and Jadesola recalled her readings on the TLQ after everyone had taken their readings
Accomplishment of tasks	Jadesola accomplished 3 tasks independently and missed the fourth because she did not wait for the TLQ to be ready before pressing the data collection button. She couldn't continue because the liquid had already cooled by the time TLQ was navigated to sensor page. Jadesola insisted on doing the activities by herself.

Table 7.5: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observations of Jadesola working with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/ Topic	Basic science: Determination of temperature and pH of two liquids
Engagement	Jadesola was seen engaged with the apparatus when it was her turn. Each time the sighted guided her hands to apparatus since there was no work tray.
Participation	She participated in her group work, interacted with others and took turns in all the laboratory periods observed. Requested her classmates to be quiet so she could hear the voice of the TLQ
Support received	The sighted classmates guided her hands and made available what she needed, but not in the experimentations. The teacher also explained the steps before the students touched the apparatus and she also moved round and repeated the steps to Jadesola when she finished taking the temperature of the first liquid.
Accomplishment of tasks	Jadesola accomplished three experiments, but received support on one that she missed but still did not get the right readings.

Table 7.6: Summary of the findings of observation of Maryam during science lessons

Technology in use by SVI before	Mobile phones, tape recorder, computer,
Independent performance of tasks	Maryam was assisted by a sighted friend within the classroom, laboratory and other sections in the school compound. She also struggled with the arrangement of the apparatus to be used for the experiment because no particular pattern was followed. However, she measured the temperature and pH of the liquids supplied on her own successfully.
Support	She independently performed the experiment and politely refused help or support offered by sighted peers after she had mastered the procedure. She sometimes said “Let me try, I can do it alone thank you”.
Braille textbook	No braille textbook for science
Use of resources	She handled the resources properly by the second laboratory work, operated the Talking LabQuest when it was her turn in the group activities.
Progress and method of delivery	The teacher explained the procedure. The pace was all right for Maryam as the teacher repeated the procedure when Maryam asked, since she could not see the writings on the chalkboard.
Effect of the use of talking LabQuest during lessons on sighted classmates	The students were initially distracted, but the eagerness of independent performance by the visually impaired made the sighted pay more attention and they were not distracted after the first lesson. Maryam worked with three sighted students in two different laboratory tasks. She operated the LabQuest when it was her turn, while others recorded readings in their notebooks as they listened attentively to the voice coming from the LabQuest. She retrieved the data earlier saved on the LabQuest and showed the members of her group to crosscheck with their written data.
Accomplishment of tasks	Maryam performed the four experiments successfully.

Table 7.7: Overview of the findings on engagement, participation, support received, independence and accomplishment of task in overall observations of Maryam working with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/ Topic	Basic science: Determination of temperature and pH of two liquids
Engagement	Maryam was active and listened to the teacher's explanation of steps to be followed. She understood the functions of TLQ as she was asked to operate all the functions of the buttons on the TLQ during the training. She could operate the TLQ vey well.
Participation	She participated and cooperated with the group members as she was happy to be involved. The sighted classmates in the group were also happy. They allowed her to start the experiment each time.
Support received	Supported by the sighted classmates, the TVI and the science teacher, especially in supplying the apparatus, the liquid and guiding the hands of Maryam towards the conical flask after completing measurement of the one liquid before starting another one.
Accomplishment of tasks	Accomplished the four experiments successfully.

Table 7.8: Summary of the findings of observation of Jolade during science lessons

Technology in use by SVI before	**Mobile phones, MP3 player, computer**
Independent performance of tasks	Jolade needed sighted assistance to move within and outside the classroom, laboratory and other sections in the school compound. Science activities were done in groups and students took turns. Jolade performed her experiments independently. he shouted at classmates who tried to do it for her.
Support	Sometimes rejected help or support offered by sighted classmates. Sometimes shouted when sighted classmates tried to do her work for her. For example, a groupmate helped her to plug temperature probe in the TLQ, she removed it and replaced it back.
Braille textbook	No braille textbook for science
Use of resources	She handled the resources properly. Even shouted to remind classmates to save her readings to be able to work on the readings after the lab work.
Progress and method of delivery	The teacher explained the laboratory activity before the students interacted with the apparatus. Jolade took turns with the others in the group, spent similar times to collect her readings since it was the same TLQ. Progress and delivery was all right for her.
Effect of the use of talking LabQuest during lessons on sighted classmates	Jolade worked with three sighted students in two different laboratory tasks. She performed the experiment when it was her turn, Sighted classmates also saw the readings on the screen of the TLQ. Sighted students who were not in the SVI group used mercury-in-bulb thermometer, they recorded in their notebooks and tried to change group during subsequent practical.
Accomplishment of tasks	Jolade accomplished the four (experiments) tasks independently. She was assisted by her sighted classmates in the group to arrange and move the apparatus close to her since there was no work tray. She also worked on the data after class.

Table 7.9: Overview of the findings on engagement, participation, support received, independence and accomplishment of task in overall observations of Jolade working with TLQ

Items	**Observation during lessons with Talking LabQuest**
Subject/Topic	Basic science: Determination of temperature and pH of two liquids
Engagement	Jolade was engaged with the apparatus while measuring the temperature and the pH of the samples supplied by the teacher. She followed the steps listed in Appendix Vb and ask the teachers questions.
Participation	She participated in the experiments, since each student was allowed to take turns. Actively she did her own portion and listened as the TLQ voiced the readings of the classmates
Support received	She received support from the classmates, the TVI and the teacher. The classmates always arranged what she needed for the experiment close to her when it was her turn, and the teacher moved round to re-explain the steps and sometimes watch as she performed the experiment.
Accomplishment of tasks	She did the four experiments successfully.

Table 7.10: Summary of the findings of observation of Joseph during mathematics lessons taught with STEM Kit

Technology in use by SVI before	Mobile phones, tape recorder, typewriter
Independent performance of tasks	He moved without assistance within the classroom but was led by sighted classmates outside the classroom. Used the STEM Kit with confidence; he required assistance during the first lesson on all the questions solved, but eventually did the task in subsequent lessons without help.
Support	He was supported by sighted peers and the teacher, especially after one question. Returning the tiles to appropriate section on the metallic board posed a problem. He improved on the third lesson observed. He claimed to practice well after school with sighted classmates.
Braille textbook	No braille textbook for mathematics
Use of resources	Joseph solved the questions on his own by arranging the tiles on the metallic board after the first lesson. He initially had a problem with it but gained confidence later although spent more time.
Progress and method of delivery	The teacher wrote on the chalkboard and read out more than 50% of what he wrote. The pace was okay as the teacher allowed each SVI to proceed at individual pace. Some SVI were able to do more questions than others.
Effect of the use of STEM kit during lessons on sighted classmates	The students were initially distracted, but they later concentrated on their work, as it was a revision class for them and a specially organised class. The teacher's attention was more on the SVI during the lessons with STEM kit.
Accomplishment of tasks	Joseph was able to solve 6 questions and got all of them right.

Table 7.11: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of <u>Joseph</u> working with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/ Topic	Mathematics: Addition, Subtraction and Division of numbers, Simple Equations
Engagement	He was engaged from the beginning of the task, individually arranged and solved questions given as classwork. Example: 230 +.480 = ?; 4X =20 what is X ?(See Appendix Vb for the remaining tasks).
Participation	Joseph got all the tasks right, but spent more time than the sighted. Especially the time it took to return tiles to the original positions. This was manifested more during the first lesson with the STEM Kit.
Support received	The teacher assisted him to align the tiles on the metallic board and illustrated the example on his board before being asked to solve questions on his own.
Accomplishment of tasks	Accomplished 6 questions successfully.

Table 7.12: Summary of the findings of observation of Ade during mathematics lesson taught with STEM Kit

Technology in use by SVI before	Mobile phones, tape recorder, typewriter
Independence performance of tasks	Ade was led by sighted peers within and outside the classroom. Used the STEM Kit with confidence. He required assistance in all the tasks in the first lesson with the STEM Kit but eventually got used to it and did the task on the third lesson without help.
Support	He was supported by sighted classmates and the teacher, especially after the first question, he was supported when returning the tiles to the appropriate section on the metallic board. He improved by the third lesson observed, he claimed to practice well after school with sighted classmates.
Braille textbook	No braille textbook for mathematics
Use of resources	He solved the questions on his own by arranging the tiles on the metallic board in the third lesson. He initially had a problem with it but gained confidence later.
Progress and method of delivery	The teacher wrote on the chalkboard and read out more than 50% of what he wrote. The pace was okay as the teacher allowed each SVI to proceed at individual pace. Some were able to do more questions than the others.
Effect of the use of STEM kit during lessons on sighted peers	The students were initially distracted, but they later concentrated on their work. It was a revision class for them. The teacher's attention was more on the SVI during the lessons with STEM kit.
Accomplishment of task	Ade was able to solve 5 questions successfully while he got the others wrong after seen trying to solve them.

Table 7.13: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Ade working with STEM Kit

Items	**Observation of lessons with STEM kit**
Subject/ Topic	Mathematics: Addition, Subtraction and Division of numbers, Simple Equations
Engagement	He was engaged from the beginning of the task, tried to arrange the tiles by himself but the sighted classmates who sat close to him assisted him and the figures 0 to 9 were arranged on the left side of the metallic board. The operational signs were arranged to the lower right of the metallic board. He solved question 1, 4, 5 and 6 given as classwork. (See Appendix Vb for the tasks). Was nervous and confused when solving the first question.
Participation	Ade was able to solve only four questions. He spent more time than the other SVI and the sighted classmates because he initially felt he could continue the next questions without returning the tiles to the initial positions. It manifested more during the first lesson because he was only able to solve one questions before the lesson period was over.
Support received	The teacher assisted him to align the tiles on the metallic board. The sighted classmate sitting next to him assisted him to find tiles when it was scattered on the metallic board.
Accomplishment of tasks	Accomplished 4 questions during the 3 lessons observed.

Table 7.14: Summary of the findings of observation of Adediran in mathematics lesson taught with STEM Kit

Technology in use by SVI before	Mobile phones, tape recorder, typewriter
Independent performance of tasks	He was led by sighted classmates within and outside the classroom. Used the STEM Kit with confidence although he required assistance on all the tasks solved but eventually got them right.
Support	He was assisted by sighted classmates to locate the tiles but the assistance reduced greatly by the third lesson observed.
Braille textbook	No braille textbook for mathematics
Use of resources	He solved 5 questions on his own by arranging the tiles on the metallic board. He missed out a few steps but as in the operational explanations he was able to use the resources properly.
Progress and method of delivery	The teacher wrote on the chalkboard and read out more than 50% of what he wrote. The pace was okay as the teacher allowed each SVI to proceed at individual pace. Some were able to do more questions than the others.
Effect of the use of STEM kit during lessons on sighted classmates	The students were initially distracted but they later concentrated on their work, since it was a revision class for them. The teacher's attention was more on the SVI during the lessons with STEM kit.
Accomplishment of tasks	Adediran was able to solve 5 questions successfully

Table 7.15: Overview of the findings on engagement, participation, support received, independence and accomplishment of tasks in overall observation of Adediran working with STEM Kit

Items	Observation of lessons with STEM kit
Subject/ Topic	Mathematics: Addition, Subtraction and Division of numbers, Simple Equations
Engagement	He was observed arranging, picking and returning tiles from the beginning of the lesson. Individually arranged and solved most questions given as classwork. Example 230 +.480 =?; 4X =20 what is X? (See Appendix Vb for the remaining tasks)
Participation	Adediran got five questions right because he spent more time on the first three questions. Especially the time it took him to familiarise with the layout of the board and returning tiles to the original positions after the teacher had orally marked the question. This was manifested more during the first lesson.
Support received	The teacher assisted him to align the tiles on the metallic board, explained and corrected his mistakes.
Accomplishment of tasks	Accomplished 5 questions successfully

7.2.2. Discussions of the findings from observations

The discussions are presented focusing on the key findings from the observation of all the lessons, the access to the curriculum, engagement during activities and independence/independent learning. The discussion is also extended to the effect of the context of study school 2 on the independence of the SVI.

Access to the science and mathematics curriculum

The findings from Tables 7.2 – 7.15 show that with the STEM Kit, JSS1 SVI (three pupils) were able to access the mathematics curriculum despite being newly introduced to the subject. Also, the JSS3 SVI (four pupils) performed all the laboratory activities in science successfully like their sighted classmates. Considering these were observations of the JSS1 who were not attending mathematics lessons in study school 2 before, the three SVI solved between 4 to 6 questions during the three lessons observed. It is true these were questions meant for students in primary school, but without the knowledge of simple mathematics students will not be able to solve complex or more advanced questions. The lessons with the STEM Kit built on their rudimentary understanding of arithmetical operations learnt in primary school and informally from their homes. The sighted teacher was able to move round the students and gave illustrations/explanations regarding questions earlier presented on the chalkboard. While more questions were given to the sighted, the SVI could proceed at their own pace, moving to Question 2 after solving Question 1. The visually impaired spent some time returning the tiles to their appropriate places on the metallic board before starting another question.

Similarly, in Basic Science, Opeyemi, Jadesola, Maryam and Jolade had access to the science curriculum, unlike before when such activities would just go on and the SVI would be in the midst without being carried along.

The findings also showed that the lessons were taught by sighted teachers who did not have any knowledge of braille or specific needs of the SVI. Without any influence from the specialist teacher, the sighted teacher was able to illustrate how to solve mathematical questions to the SVI. The teacher was also able to mark (though orally) the students' work.

Engagement in class activities

Engagement with TLQ as illustrated here is different in some ways from engagement with the STEM Kit. From the findings presented earlier, it was clear that the four SVI in JSS3 were able to measure the temperature and pH of the liquid supplied. Jadesola's readings in one of the experiments was wrong, but others measured and got the correct readings in all the experiments. They took control of the TLQ and other apparatus whenever it was their turn and particularly refused help from classmates when unnecessary.

With the STEM Kit, all the SVI in JSS1 were involved in the learning throughout the lessons. They were either looking for particular tiles, picking a tile or returning tiles to original position on the metallic board, or raising a hand to invite the teacher to see their work or explain further on the topic to them.

Independence/Independence of learning generally

From Tables 7.2 – 7.15, independent performance of various activities was repeated in many reports of the observations. For instance, the SVI in JSS1 (Joseph, Ade and Adediran) who were taught mathematics worked on their own with the STEM Kit. After the trainings, they still explored the resources, especially the STEM Kit as each of them was given a Kit for the period. It was used with sighted friends to solve some basic mathematics after school hours. This gave them confidence during the class activities. Ade initially felt he could do another question without rearranging the used tiles back to the original position on the metallic board, but he was frustrated by the effort he had to put in place and eventually was unable to solve another question that day.

Generally, the unorganised classroom arrangement and school compound made all the SVI dependent on the sighted to move within and outside the classroom. All of them, except Joseph who possesses some vision, were led by their sighted friends. Relating the findings to the ECC, the findings suggest that the three SVI in JSS1 also accomplished the tasks given to them by the teachers because they could read the braille on the tiles. It meant that they possessed some compensatory skills (braille, tactile), while the JSS3 students also displayed use of auditory skills when TLQ voiced the temperature and pH readings. Their inability to move individually within the classroom and school suggests they are poor in O & M, this also affected their self-determination as they were left at the mercy of the sighted classmates.

In terms of the use of assistive technology, all the seven SVI used telephones, and all of them were proficient in the use of typewriters, because they answered questions for sighted teachers of other subjects with typewriter. The nonlinear nature of some questions in mathematics makes it difficult for them to be solved with typewriters. In the same way, diagrammatic representation of concepts is impossible. As at the time of this study, only four of the seven SVI are proficient with the use of a computer, they had learnt it from home because there was no accessible computer among the few computer systems available in the school. Two of the students used MP3 players to record lessons, but the majority relied on sighted friends to dictate notes after the lessons. However, they always faced problems getting notes. Since SVI students were given optional accommodation in nearby primary schools for the blind it was always difficult for them to copy notes after school from sighted classmates who were day students. Therefore, they always tried to do as much as they could before the school closing time every day, and they moved about in school with their slate and stylus.

In conclusion, the SVI were able to access the mathematics and science curriculums like their sighted classmates. This was likely due to the improvement in the communication between students and teachers occasioned by the STEM Kit, as Cryer (2013) identified that this could improve the access of STEM subjects to the SVI, so that teachers would be aware of what blind/partially sighted students needed.

The TVI in the school, despite being partially sighted, was very supportive when the resources were used. He ensured that the laboratory wares needed were supplied. When the hot water finished, he even went to a nearby building to secure hot water in order to allow the SVI to experience experimental science, unlike the theoretical science they are used to. This implied that the SVI also received improved support from the TVI and the teachers during the intervention. This was different from the support received before the intervention

The next section presents the analysis of email interviews with the teachers, and of focus group discussions with the SVI and their sighted classmates in study school 2 together as presented in Chapter 6. The chapter also includes a broad methodological triangulation of findings from the three methods. Finally, the specific implications of the study for study school 2 have been highlighted.

7.2.3. Analysis and discussion of findings from email interviews and focus group data

This section presents the analysis and discussion of findings from staff email interviews and students (SVI and sighted classmates) focus group discussions. This are discussed together to bring about richer findings from the three stakeholders. This will later be triangulated with findings from observations in the next section.

As explained in Chapter 4, two of the three teachers embedded their responses in the body of the email and the third teacher sent the response attached to the email. The response of the third teacher was received after five reminders, and it was sent using a PC and not with mobile phones like the other two teachers.

Each email response was copied into the appropriate source document in the NVivo project file, and the data were coded following the same steps as in study school 1 . The themes were decontextualized, as in Chapter 6 following the same pattern explained in Chapter 4.

Similar themes were considered as for study school; 1; some issues discussed with SVI were not considered necessary for the sighted classmates, and some were not included in the teachers' emails. Therefore, the themes are not the same. However, the following themes were considered for the presentation:

1. Usefulness of the resources
2. Weakness of the resources
3. Feelings of the sighted, and impact of the resources on the sighted classmates

4. Impact of the resources on the understanding of the SVI
5. Impact of the resources on engagement/independence of the SVI
6. Dynamics/strengths of the focus group
7. The perceived change in ECC competency of the SVI

The themes are either considered separately for the TLQ and STEM kit, or together, depending on the findings. The reports are supported with excerpts from the data and these are italicised.

Usefulness of the resources

On the STEM Kit**,** the basic science teacher, mathematics teacher and TVI as well as SVI and the sighted classmates in study school 2 expressed that they had a good experience with the STEM kit, as it brought succour to the SVI, their sighted classmates and in fact the entire school. The following excerpts corroborate that:

> *“The STEM kit was a good experience, because it allowed me teach Mathematics, albeit rudimentary, to the students with visual impairment.” [CS201]*
>
> *The teachers also emphasised that the kit allowed the sighted teachers to teach the SVI without much stress, and the intervention of the special teacher.*
>
> *“The STEM kit enhanced the ability of the teacher to correct the mistakes of SVI as the teacher can see for himself what they are doing” [CS201]*

Similarly, the enthusiasm of SVI suggests that the resources are useful. For example, Ade, Jadesola, Maryam, and Opeyemi reported that the STEM Kit was used for solving calculations in this excerpt: *“We used it to do calculations, workings”* and Joseph said *“calculations that are difficult for blind people are now much easier”* with the STEM Kit. Opeyemi and Adediran expressed further that the

STEM kit helped them to do mathematics since a blind person cannot use pen and paper. *"It also makes it easy for sighted teachers to teach and correct our work"* [VI21]. It is interesting that the JSS3 also commented on the STEM Kit from the after-school experiences shared with the JSS1.

The sighted classmates also expressed that the resources were useful to SVI, each of them were able to mention the uses of the STEM Kit, as expressed in the following excerpts: Joke and Titi reported that STEM Kit was used to solve mathematics questions.

> *" ... they used it to solve mathematics questions when the sighted used their notebook and pen" [S 21].*

The sighted classmates further raised a key strength of the STEM Kit, that the dual information on the tiles (braille and print) made it possible for the sighted teacher to explain, and even correct their mistakes as they do to the sighted. This also allowed sighted and SVI to work together after lessons as reported in the following excerpts:

> *"Teachers were able to guide and correct their work as they do for the sighted" [S26].*
>
> *"They correct them when they make mistakes" [S25].*
>
> *"We sighted students will be able to work together after lessons" [S21].*

On the TLQ, all the teachers including the TVI expressed that they found the TLQ very useful. Recounting his experience, the basic science teacher said

> *"It was great using the Talking LabQuest to measure temperature. The resource was just a timely intervention to my concerns of how to make these SVI students have access to hands-on learning like*

their sighted friends rather than the abstract learning that does not make them feel included" [CS202] .

She also expressed that:

"The Talking LabQuest is a very useful tool for teaching the SVI, particularly as most science topics are difficult to teach abstractly".

There was also evidence that the TLQ enhanced the teaching and learning of science and mathematics. The Basic Science teacher expressed that there were positive changes in participation and learning of the students:

"There was change in the participation of the SVI during this lesson as the talking LabQuest really made the SVI feel like they are actually learning" [CS202] .

"For instance, students like Opeyemi who seems to be always quiet during lessons was particularly very active and asked lots of questions which demonstrated he has really understood the lessons" [CS201].

The students also commented on TLQ. Maryam said that:

"It was telling us the temperature readings. We used it to measure temperature" [VI23].

While Opeyemi and the rest said *"we use it to collect data"* The sighted classmates also expressed that TLQ was useful for the SVI in the following excerpts:

"It measured the temperature of solutions" [S22].

"They used it to collect and record data" [S24].

"They used it to calculate" [S23].

All these expressions suggest that TLQ was useful for SVI and all the stakeholders liked it.

Weakness of the resources

The teachers, SVI and sighted classmates identified that it was not possible for SVI to save solved questions for future reference. This is a weakness. For example, the mathematics teacher reported that:

> *"Its weaknesses may be the inability of the work to be revised by the SVI because the arrangement is always destroyed after each use". [CS201]*

And for the TLQ, the SVI suggested that the voice should be slowed down in this excerpt:

> *"The voice should be slowed down a little because we would be able to hear clearly" [VI22]*

Impact of the resources on sighted classmates

When the sighted classmates were asked if they were affected when the SVI used the resources, they all reported that they were not negatively affected. When asked if they wanted the SVI to use the resources during the lessons they equally said "Yes" together. They were silent when further asked for a counter-opinion (social-desirability effect). All this suggests that they were not affected, although it is important to note (as explained under Methodology) that the classroom used for the mathematics lessons was not the usual classroom. Could this have affected the responses of the students? Triangulation of this finding with that of observation might possibly clarify the issue.

Impact of the resources on understanding of the lessons by SVI

Regarding the STEM Kit, responses suggested that the SVI preferred the ones taught with the Kit:

> *"I prefer the one with STEM kit than the one the teacher taught orally because we were able to participate in the class". [VI21]*

Similarly, they preferred lessons taught with the TLQ, and even pointed out that they were able to record real time data, which was not recorded for them by an assistant or totally excluded from lessons like before:

> *"If we are taught orally, we would not have experience of how to measure temperature. It is better than the oral teaching" [VI21].*
>
> *"The sighted were able to write the readings in their notebooks, the LabQuest stored my own data" [VI23].*

Impact of the resources on engagement/independence of SVI

The teachers in study school 2 identified some strengths of the STEM kit. One of them said:

> *"Its strengths include: more enthusiasm of SVI to practical work, more individualistic work and elation". [CS201]*

The SVI gave a chorus response when they were asked if they were able to work independently, and Opeyemi responded further that:

> *"Lessons without it is not easy, it is somehow stressful, and students will be racking their brain instead of physical involvement in the calculations" [VI21].*

In addition, the sighted classmates also expressed that the resources helped them to understand and participate in the lessons.

The TLQ, according to the students, helps blind persons to measure temperature.

> *“When they were measuring the temperature they were able to listen to the voice of the readings displayed on the screen of the TLQ”.[S26]*

These responses suggested that they were able to work relatively independently on class activities. Furthermore, they were asked to compare lessons taught with and without the resources. Joke said:

> *“The one taught with TLQ was better” [S23].*

Following this, Yinka said:

> *“They are active when the Talking LabQuest was used” [S25].*

Similarly, Jumoke reported that lessons with STEM Kit were also better than lessons without it:

> *“They participated better when the STEM Kit was used” [S26]*

and Joke also reported that:

> *“They solved questions given just like the sighted and the sighted teacher moved round to explain to them. Just as he does with the sighted”. [S23]*

Further comparison was made by Yinka and Jumoke that the SVI were more engaged and learned better when the STEM Kit was used, compared with when the resources were not used and they were passive listeners.

> *“They were able to show teachers their calculations when the STEM kit was used but only listen when STEM kit was not used” [S25]*

> *“Yes, that is even when they stayed in class, they usually leave classroom when we have mathematics” [S26]*

and Titi concluded that:

> *“STEM Kit allows them to participate like sighted students” [S21]*

Dynamics/Strength/Characteristics of the discussion

The dynamics/strength/characteristics of the discussion are not relevant with email interviews. However, relationships within the groups, agreement or disagreement between members and whether there is a consensus of opinion, or a shared understanding, are recorded by the scribe during the focus group discussions with SVI and sighted classmates.

There was a cordial relationship between the members in both groups, and they agreed on a number of issues. For example, when asked if the STEM Kit enabled them to individually participate in the lessons there was a chorus answer of "Yes". For some of the questions, once a member answered the questions they keep silent even when asked if there were other responses. This shows agreement with the previous response. There was no disagreement on issues. The body images recorded by the scribe suggested a happy disposition of the members, which may mean that since they had been able to do things that were normally considered impossible, they were happy. They displayed good social skills. Opeyemi seems to dominate the discussions as he has more responses than other members in the group.

The dynamics of the discussion were not strong in both groups, as they seem to agree easily on issues or give a chorus answer., This could be attributed to their happiness for SVI. Kitzinger (1994) reported that different dynamics could be witnessed in focus groups, depending on the topic and the composition of the group.

Impact of the resources on ECC possessed by the SVI

There were no direct questions on the ECC during the focus group discussions with the sighted and SVI. However, the reports of the scribe show some information on the ECC skills. The findings suggest that SVI developed their social interaction skills during the period of intervention, because the sighted classmates stressed that they were able to study together with the STEM Kit since the sighted classmates could read the print, and SVI could read the braille on the tiles. As mentioned in Chapter 6, there are no definitive tools to measure the ECC components, but the sighted emphasised that they enjoyed lessons taught with the resources. They displayed good self-determination with the enthusiasm with which they attended the classes, not minding their previous experience (phobia for mathematics and diagrams). There is not enough evidence on the acquirement of some aspects of the ECC. The activities provide opportunities for engagement with mathematics, science and the ECC, and the students seemed to do this successfully. The findings suggest that the more they engage in these activities the more they will hopefully develop. The context of study school 2 did not give the participants a marked setback. Though they seemed lacking in O&M skills, they still possessed some compensatory, career education, self-determination skills which motivated them to participate in the study with such enthusiasm.

7.3. Triangulation of data

As in Chapter 6, the findings from the observations were cross-analysed with findings from email interviews and focus group discussions already discussed. A major difference in the findings from the observations was that these included the non-verbal actions of the SVI, and some other information not considered important by the teachers and so not mentioned in the email interviews, or by the sighted and SVI and therefore was not mentioned by the focus group.

There is no contradiction in the findings from the three methods. The data suggest that the SVI had access to the curriculum, they improved in participation, engagement and independence during classroom activities. However, observation data was more detailed as explained in chapter 6.

From the observations, the findings show that the sighted peers were to some extent neglected by the teacher during mathematics, but the neglect was not shown in their scores, as they were being taught rudimentary mathematics that they already knew. This was not reflected in the email interviews of the teachers and the focus group discussions with SVI. The sighted classmates in JSS3 who worked in the SVI laboratory groups also counted themselves lucky because those in other groups used the mercury-in-bulb thermometer for measuring temperature, and litmus paper and a pH meter to identify acids and bases. Each student tried to join the group with SVI during the practical exercises.

Findings from the three methods revealed that SVI were seeing picking and arranging the tiles, fully engrossed on the work in the classroom. The STEM Kit was used by individual students, and their assessments were individually done at their own pace. TLQ was also used by each student in the group in turn, and they were also engaged in the laboratory activities. These were clearly captured during observations of the lessons.

Some weaknesses identified from the observations with STEM Kit were not mentioned during the focus group discussions, and they were not reflected in staff response to the email interview. Such as, the stress of returning the tiles to previously arranged positions before starting new question. Similarly, the inability of SVI to keep their workings for future reference was also observed, and was not mentioned by the stakeholders. It was observed that SVI felt reluctant to clear the workings after the teacher had orally assessed their work. Initially they also found returning the tiles to their former places difficult, but the time it took to return the tiles reduced by the third lesson observed.

7.4. Implications of the findings for study school 2

SVI found the resources very useful. The teachers and the sighted classmates also reported that the resources were useful. The SVI were able to solve mathematical questions with the STEM Kit, and the TLQ was used for measuring temperature and pH of solutions.

However, the findings have some implications for individual SVI, the science and mathematics teachers, the heads of the schools, and the government of the state where study school 2 is located. The implications are discussed below:

7.4.1. For the individual SVI

Emphasis on the need for the SVI to learn the newly introduced UEB braille was raised. As, at the time of this study, the TVI in the school were not much familiar with UEB, although they showed great interest and learnt the UEB signs in the few tiles used. One of the research assistants used during the data collection was assigned to visit the school at least once weekly to sustain the change. Information reaching me shows the TVI and the SVI have been undergoing the training and are becoming more proficient using the STEM Kit. However, the teachers teaching science and mathematics in both junior and senior school were also using the Kit and TLQ for the SVI, on an average of once a week, on days when the research assistant visits their school. Sometimes the Principals support the transport fare of the research assistant, showing their interest and support for the change. The principal had incorporated the purchase of resources into 2016 school budget. The parents of two students also requested to purchase a STEM Kit for their children, and it has been sold after the copyright registration of the Kit which contains additional components (more tiles and diagrams with braille and print labels).

The mathematics teacher has been transferred from study school 2, so the TVI and research assistant are the ones sustaining the change, teaching the students outside the mathematics period. The Principal is working on getting the mathematics teacher posted back to the school.

The importance of the ECC, which is the additional curriculum required to achieve success in conjunction with the core curriculum, was explained, and the SVI were advised to focus more on acquiring those skills. They also needed to find additional time to practice using the Kit, so that the teacher would be able to teach the mainstream class without putting the sighted classmates at a disadvantage. Similarly, further training and practice is necessary on the use of TLQ.

7.4.2. For the science and mathematics teachers

There was also a need for the teachers to familiarise themselves with the use of the resources, such that the sighted classmates would not be at a disadvantage when involving SVI in a mainstream class. There is a need for regular training on the use of these and other resources, to ensure proper inclusion of SVI in science and mathematics. The teachers should request the TVI to produce questions to be solved during each lesson in braille. To be able to do this, the TVI need special training on the mathematics braille code, and the techniques of adapting resources used for the sighted classmates. These were recommendations passed before leaving the school, but the research assistant reported that the teachers also participated in weekly training when they had free periods in the school. The STEM Kit is being used during lessons especially for those who have already purchased the copyrighted Kit.

7.4.3. For the head of study school 2

The Principal of study school 2 needs to improve on the facilities in the school environment, to reflect the mainstream nature of the school. The unorganised arrangement of the classroom, laboratory and school compound were a barrier to their independence (O & M skills). All the SVI, except Joseph with his limited vision, used a sighted assistant to move within and outside the classroom. This has a negative effect on their independence, as they are left at the mercy of the sighted peers even for simple activities. Specific adaptations to the environment needed urgent attention. However, nothing has been done on the physical facilities according to reports from the research assistant and the TVI.

The findings also have implications for the government of the state where study school 2 is situated. First, the facilities in the school, as explained in Chapter 4, are inadequate for the sighted and VI leaners in the school. The effect of the non-inclusive environment impacted on the independence of the learners with visual impairment, because they relied on the sighted for virtually everything that could often be done independently: for example, moving within the school environment. The number of laboratories, computers and even seats for students are inadequate. The findings from this research provide evidence of the usefulness of targeted equipment and interventions like the STEM kit and the TLQ. The LabQuest could also be provided for sighted students, and this will likely improve the standard of education in the school generally.

The broader implications are discussed in the next chapter.

CHAPTER 8. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

8.1. Chapter overview

This final chapter presents an overview of the aims and research questions of the study, followed by a broad discussion of the findings in Chapters 6 and 7. It also presents an overview of the entire study, starting from the exploratory study to the AR in the two study schools**.** Also, presented in this chapter are the implications of the findings to SVI in the study schools, the SVI in other schools, the management of the study schools, the teacher trainers, the Nigerian government and other stakeholders. This chapter also appraises the approaches adopted for this study, drawn conclusions from the study and finally, offers recommendations for further research.

8.2. Overview of the aims and the development of the research questions

The study commenced with the title Innovative strategies for enhancing enrolment of sensory impaired students in sciences in Nigeria", with the initial aims of exploring and establishing innovative strategies of enhancing involvement and active participation of students with sensory impairment (hearing and vision) in sciences, the following initial questions were the focus of my research:

1. What are the factors responsible for low enrolment of sensory-impaired students in science courses?

2. How can we enhance the enrolment of sensory-impaired students in Science Courses?

Interestingly, the entire study reflected my initial proposal in some ways. My entire study involved exploration and developing strategies of enhancing enrolment of only SVI rather than broadly sensory-impaired, which includes the deaf and hearing-impaired. The first research question was explored in the exploratory study that was reported in Chapter 3 of this thesis. The study explored the reasons for low enrolment or non-access to sciences by the SVI. The research adopted a survey design, used telephone interviews and a postal questionnaire to collect data from sampled SVI and science teachers. Although there were many limitations to the study, useful and meaningful findings were obtained which helped shape and justify the research as it progressed. The second research question was refined, and an action research (AR) study was adopted. Specifically, the AR was used to evaluate the impact of two interventions (Talking LabQuest and a self-developed Special STEM Kit) on the participation of SVI in Basic Science and Mathematics in junior secondary schools in South-Western Nigeria. Specifically, the study examined the impact on:

(a) Students' engagement in science and mathematics;

(b) Students' level of independence during science and mathematics lessons;

(c) The influence of SVI competency in expanded core curriculum (ECC) on participation and independence in basic science and mathematics activities; and perhaps the influence of the activities on their ECC competency;

(d) The perceptions of all students (including sighted children) regarding the Talking LabQuest (TLQ) and the STEM Kit as learning tools; and

(e) The perceptions of teacher(s) regarding the use of the resources as teaching tools.

The research questions became the open-ended type, as AR participants are considered as co-researchers, and the research involved reflections at different stages in the spiral structure. The research questions explored in the whole research are:

- RQ1 How do teachers teach Basic Science in a mainstream class with SVI?
- RQ2a What are the main difficulties SVI faced in a regular science class?
- RQ2b What strategies do students used to overcome these difficulties?
- RQ3 How can the problem of access to science by the SVI in South-Western Nigeria be solved?
- RQ4 What is the impact of Talking LabQuest (TLQ) and the STEM Kit on the participation of SVI during Basic Science and Mathematics lessons?

RQ1 to RQ3 were addressed within the exploratory study reported in Chapter 3, and parts of the literature reviewed in Chapter 2. The exploratory study represented a useful and insightful ‘first go’, and offered evidence that the concerns were well founded, but it had not satisfactorily answered the research questions. Therefore, six search conferences were organised in five of the six states in South-Western Nigeria to further RQ1 to RQ3. The search conferences also represented the Observation/consultation and Reflection stages of the AR cycle. The procedure is presented in Chapter 4, and the findings, recommendations and reflections on the findings of the search conferences are presented in Chapter 5. While the last research question RQ4 was addressed in the two study schools which represents the Action part of the action research cycle. Before the actions in the two schools there was a Planning stage when TLQ was procured and the STEM Kit was designed and piloted. The details were presented in Chapter 4. The intervention in the two study schools is presented in Chapters 6 and 7. Finally, the discussions, implications and recommendations in Chapter 8 represent the last stage in the AR cycle, of Reflection, that is expected to lead to the next cycle. The AR cycle is summarised as shown in Chapter 4.

8.3. Discussion of the findings from the action research in the two study schools

The discussion is presented in relation to the key focus of the RQ4, which is on the evaluation of the STEM Kit and the TLQ. The discussion brings together the findings presented in Chapters 6 and 7 from the two schools, which are drawn from observations of the classroom and laboratory lessons, email interviews with teachers and focus group discussions with SVI and their sighted peers.

Sets of similar themes emerged from the presentation of results in both Chapters 6 and 7, and therefore this discussion is presented under a summary of the themes, which are supported with excerpts from the results, and are also linked with literature and the theory already expounded in Chapter 2. The summarised themes comprise:

1. Access to the STEM curriculum,
2. Engagement in class activities,

3. Independence / independence of learning,
4. Impact of the resources on sighted classmates,
5. Weaknesses of the resources, and
6. Perceived change in the CC competency of the SVI.

8.3.1. Access to the science and mathematics curriculum

The findings presented in Chapter 6 and Chapter 7 suggest that the SVI gained improved access to the science and mathematics curriculum presented in the mainstream classrooms, following the introduction of the intervention. It enabled them to access the curriculum equitably like their sighted classmates, despite the different contexts existing in the two schools. Evidence from observations and consultations with students (sighted and SVI) and teachers supported this.

This agrees with Sahin and Yorek (2009 p.20), that “visually impaired students can learn anything and achieve the same success as their sighted peers do”. Similarly, Kumar et al (2001) report that visually impaired students have the same range of cognitive abilities as sighted students. Jones, Minogue, Oppewal, et al., (2006) believe that they can master higher-order science concepts just like the sighted if adequate and appropriate accommodation is made by the teacher/school.

The presentations also reflected that the lessons were taught by sighted teachers who are non-specialist, and have never attended Special Education training, despite having taught in mainstream schooling for at least six years. As mentioned in the literature review, Norman, Caseau and Stefanich (1998), in a survey of American teachers, report that over half of teachers (elementary to university) have received no training specific to teaching disabled students. Similarly, Fraser and Maguvhe (2008), report that many teachers have only had general teacher training; they maintain that these teachers lack skills, and ideas for adapting the curriculum. This suggests that it is not peculiar to Nigeria, therefore this study, in agreement with previous research, recommends inclusion of meaningful Special Education knowledge in the general education curriculum in teacher training courses/institutions.

8.3.2. Engagement in classroom activities

Unlike before, it is reflected in the findings that the SVI were fully involved in the lessons and laboratory activities. For example, in study school 1, Wale was engaged in activities with the STEM Kit, and was fully involved in group activities when TLQ was used in the laboratory, sometimes even faster than his sighted classmates. There was also evidence that he used to take almost double the time to accomplish some tasks when compared with the sighted students. The teachers supported Wale, and they were still able to teach the whole class. Dunn and Meredith (2004) expressed that with a little ingenuity and willingness to learn, disabled students can be included in a wide variety of learning situations.

In the same way, in study school 2, the JSS1 findings suggest that students were engaged with the STEM Kit when they were taught mathematics for the first time in that school, and the JSS3 were also more engaged in the science lesson with the TLQ. Their teachers also expressed their excitement.

8.3.3. Independence / independence of learning generally.

Independence is very valuable to SVI, as shown in the literature; the students have a different level of independent movement within and outside the school. SVI in study school 1 seemed to have more independent movement within and outside the classroom, because their classroom and school environment were both more inclusive than that of study school 2. The study school 2 SVI relied upon support from their sighted peers, because their classroom and environment were less inclusive. For example, Tinu moved independently within the classroom and the school compound using his remaining vision. Wale and Lekan moved independently within the classroom and school compound with the mobility cane, while Sade and Segun required sighted assistance (possibly because it was Sade's first year in the school, while Segun had additional disability). This suggests that they received necessary support from their TVI on orientation and mobility training and that their environment was more inclusive.

Commentators in the field of Visual Impairment education have broken orientation and mobility down into eight components, and emphasised that all the components are important and lead to increasing independent travel, confidence and competence that will be useful in other aspects of life, and also extend beyond the school years (Fazzi and Naimy, 2010; Fazzi and Pettersmeyer, 2001).

Furthermore, accomplishment of tasks, and support received are also related to independence. As reflected in the findings, all the five SVI in study school 1 were able to perform tasks given by the teachers during lessons successfully, although with various degrees of independence. Wale, Tinu and Sade scored 9, Lekan scored 7 and Segun scored 6 out of 10 in these tasks. The SVI in study school 2 also scored between 3 and 6 in mathematics, and were able to do the four experiments, all except Jadesola who did three experiments. Their mathematics teacher allowed them to move at their own pace. Their scores were comparable with their sighted peers. Their level of independence in the tasks can also be compared with that of their peers. The findings are in agreement with a small scale qualitative study of Sahin and Yorek (2009), which reports that: “blind students showed that they could actually perform many of the activities in experiments such as plotting graphs, measuring angles, classification of rocks and minerals, and solving mathematical problems” (p. 21). Similarly, Cryer and Gunn (2008) report the importance of learners being equipped with the right skills. The few ECC skills possessed by the SVI could be attributed to their success in the tasks, but more in-depth study is needed that will measure ECC, to directly identify its relationship with the performance of SVI in science and mathematics.

In conclusion, the SVI were able to access the same curriculum comparably with their sighted classmates. They were engaged in activities when the resources were used, unlike before, and were still comparable with their sighted peers. The support received from the teacher seemed more than that given to the sighted but it seemed compatible with the aims of the mainstream lessons. The sighted peers also appeared to benefit from the use of the tools.

8.4. Summary of findings

This chapter has presented the findings from the two study schools. The literature review presented in Chapter 2 highlighted that SVI have problems accessing STEM subjects. The problem dates back to 1930s, and is still crucial in many countries (Wild and Trundle, 2010; Wild et al. 2013b), especially in developing countries. There are improvements in developed countries, but it is not practised in the same way in all schools within these countries. The basic problems of access identified are:

1. Provision of appropriate resources that meet the needs of the SVI, and are suitable for the context of the school/country
2. Meaningful participation of SVI in classroom activities
3. The role of ECC skills in relation to access of science and mathematics.

The research questions emanated from the three key issues, and the study evaluated some science teaching resources on participation of SVI in science and mathematics, in collaboration with stakeholders, with an action research approach.

The study has answered the research questions, and the findings can be grouped into three:

1. Access to the curriculum (Have the resources supported their understanding of the subjects? Do they meet the needs of SVI in Nigerian context?)
2. Engagement / Independence (Have the resources improved engagement in activities/ Do they bring about fulfilment and happiness? Do the SVI receive adequate support?)
3. Have they any influence on the ECC or have ECC skills any influence on the use of the resources?

The findings suggest that the resources are useful, as they enabled the SVI to access the curriculum like their sighted classmates, on the topics treated, and with the SVI involved in the study.

In addition, the study suggests that the resources, especially the STEM Kit, supported the engagement/independence of students during mathematics or science lessons that require calculations (kinetic and mechanical energy) Before, without the resources. SVI participated passively (not participating in classwork or taking down homework), as reflected in the initial observations conducted in both study schools. The science and mathematics teachers had no training in education of the VI, and the TVI were not science oriented. They also have visual impairments, they could not provide any support to the SVI in science and mathematics. This tends to support a partnership model whereby TVI and science teachers would plan and execute lessons together to include SVI in mathematics and all aspects of science. This will however require more TVIs in schools to work with subject teachers. Be that as it may, the government might not provide enough TVI who could work with all subject areas. Therefore, the design of the STEM Kit provides a solution which supports engagement/independent performance of tasks by the SVI. The science and mathematics teachers see the print on the tiles, while the SVI feel the braille on the same tile simultaneously, and as such they are able to communicate. This approach draws upon teaching techniques/practices beyond science and mathematics. According to Sahin and Yorek (2009), a literature search for existing studies on instructional materials and strategies for teaching science to VI revealed that “there is a severe shortage in this area of study” (p.19).

With the TLQ, SVI were able to individually conduct their own experiments when the apparatus was supplied, in the same way as it was supplied to the sighted. Although they worked in groups, which is the norm in practical lessons, not only in Nigeria but an acknowledged practice in specific experiments all over the world (some experiments are done in groups for valid reasons). These findings supported the claim of the producer of TLQ that it supports individual performance of experiment. Early work in the field by Eichenberger (1974 p.21), suggested that “since a blind person seriously lacks skills in taking notes and recording data, it is helpful if the blind student can work with sighted peers in conducting experiments, such that his/her sighted partners can explain some laboratory activities like temperature or colour change to him/her”. This could also be likened to SVI having a note-taker, as identified by Rowlett (2008). The problems created with this approach were highlighted earlier in this thesis. However, TLQ offers the SVI more independence as shown in the findings of this study. The producer of TLQ claims that it works with more than 70 sensors, but only two sensors (temperature and pH sensors) were evaluated in this study.

Finally, regarding the influence of ECC skills. Independent performance of the SVI is the major focus of the proponents of the ECC. The findings suggest that the resources encourage and require the engagement in the ECC-type activities, which in turn will help develop these skills in the areas of career education, social interaction skills (worked successfully in a group, politely refused help offered by sighted classmates when not needed, taking different roles), self-determination, use of assistive technology (used the technology resources to perform experiments), and compensatory skills (braille reading and organisational skills required to rearrange tiles in the STEM Kit). The well organised layout of the physical facilities in the study school 1 school compound, and the classroom and laboratory arrangements, supported the O & M skills of the SVI, which are also an aspect of ECC. Whereas the School2 classroom and environment are not well organised, and this shows in the O & M skills possessed by SVI in this school.

8.5. Implications of the Research Findings

From this research came some findings which may be useful to the individual SVI, the study schools, other schools, the Nigerian government, other stakeholders involved in the education of the SVI, the service providers of learning resources for the SVI, and the theory. But before discussing the findings I want to list some findings from the literature presented in Chapter 2 which are mainly drawn from western literature and research, and are consistent with my study findings. Thereafter, in subsequent section more links to the literature are identified in spite of the tension with the different cultural settings.

1. Globally, SVI have problems entering STEM courses after secondary schools, this is an extension of the problems faced in their primary and secondary school. Although, there has been an improvement in some countries, the problem still exists, and only differs in scope and types.
2. Research evidence relating to teaching STEM subjects to blind/partially sighted students is difficult to come by (Davis and Hopwood 2001; Cryer 2013), but there is much guidance and practice-based advice on teaching STEM subjects to blind/partially sighted which are not research proven or based (although they may draw upon general approaches to inclusive teaching and material adjustment).
3. Science is seen by a number of researchers as a subject suitable for blind and visually impaired students (Norman et al. 1998; Erwin et al. 2001;

Fletcher 2011; Wild et al. 2013a).

4. Most TVI are not trained as science teachers, and have problems adapting resources in science and mathematics. Similarly, most science and mathematics teachers in mainstream schools (and even some specialist schools) lack skills and ideas for adapting the curriculum for those without sight in their classes (Norman et al. 1998; Fraser and Maguvhe (2008).
5. The way in which STEM subjects are often taught also constitutes a barrier to SVI accessing the subjects (Rowlett and Rowlett 2009; Wilson et al. 2012), although there have been many developments, like talking mathematics and learning through electronic devices. It is however recognised that some aspects of STEM are preferred to be hands-on by some SVI, and it is also difficult to take in lot of spoken information, as it can place a high demand on memory (Krizack 2000; Cliffe, 2009).
6. Producing teaching materials in accessible formats is very time consuming and costly (Rowlett and Rowlett 2009). Producing tactile graphics always requires the input of a sighted person (Ramloll et. al. 2000).
7. There is a need for a system to give blind/partially sighted students more independence (Ramloll 2000).
8. The relation of STEM subjects to the ECC, a level of ECC or some aspects of ECC, is important for access to STEM. It is also the case that STEM subjects could improve ECC skills possessed by SVI.
9. Some aspects of engaging in STEM activities (experiments) may be difficult with lack of appropriate resources and clear explanation (Cryer, 2013).

10. Poor performance in mathematics is often attributed to students being taught using the “chalk and talk” method (Rowlett and Rowlett, 2009), but a contrasting view was held by the Quality Assurance Agency (QAA 2007) that chalk and talk methods have substantial merit in mathematics teaching in higher education (SVI will be at disadvantage in such classes).

As mentioned earlier, some findings from this study were consistent with the above literature findings, however it also has its own contributions which make it different from some earlier findings.

The literature also identified gaps in research, and this study has addressed parts of the gaps as illustrated below and are further discussed in the next subsection:

1. There is a lack of-availability of suitable resources for STEM access for SVI that fit into the context of Nigeria/some African countries where the internet facility is limited.

2. There is a vacuum caused by inadequate number of TVI available in schools in Nigeria.

3. The availability is needed of relevant resources with dual nature that could be understood simultaneously by the student and teacher during lessons. This would allow immediate feedback on classwork and enhance the engagement and participation of SVI.

4. The research was situated in a real-life situation, and jointly conducted with the stakeholders.

8.5.1. Production of relevant resources for teaching

A key contribution of this study is the design of the STEM Kit for teaching some aspects of science and mathematics to the SVI. There is no contradicting the fact that SVI have problems accessing STEM subjects. Because “vision is the primary sensory system humans use for learning” Lewis and Allman (2014 p. 3), many STEM subjects rely heavily on visual resources which may be inaccessible to blind/partially sighted students, unless presented in an alternative format (Cryer, 2013). The STEM Kit made SVI able to access the curriculum like their peers in the two studied schools because of its unique characteristics.

Firstly, the design of the STEM Kit is such that it could be understood simultaneously by both the SVI and the sighted teachers who had no previous knowledge about visual impairment education. This offers a solution to the current situation in mainstream schools, not only in Nigeria, but in some other countries as well. There is a situation of inadequate specialist in schools, and the “lack of relevant knowledge” by both TVI and the science teachers that was explained earlier. These resources will not in any way replace the job of the TVI, but however they fill the already created vacuum caused by inadequate number of TVI available in schools in Nigeria, and the lack of relevant knowledge.

Secondly, the STEM Kit supports full engagement in class work requiring calculation or graphing. As proposed by the Cambourne Model and conditions for learning, that learning takes place when children are interested and engaged with the material to be learned (Lewis and Allman, 2014). In addition, that engagement occurs when high expectations are placed on the children, given opportunities to improve and practice and the provision of constructive feedback. All these conditions are met with the STEM Kit. Allowing SVI to try the questions is a sign of high expectations, ability to practice with peers using the Kit after school and the immediate feedback received in the classroom from teachers as they solve the tasks are signs of “employment” and “response” respectively Cambourne (1988) stressed that learners become engaged when they perceive themselves as potential “do-ers” because they believe that the skills being demonstrated have some purpose in their lives. Harrell (1992) and Ferrell (2011) also stressed the importance of SVI being “do-ers” and not “done-to-ers” who are always expecting people to do for them.

It also supports independent performance of tasks, as illustrated in findings from the studied schools. One of the main purposes of educating the SVI (indeed, all young people) is to maximise their independence. SVI are known to be happy to learn by doing, rather than by someone else doing and explaining to them, which avoids developing “understanding without the benefit of clear accurate visual input” (Lewis and Allman 2014). Therefore, they need direct experiences with real situations using their useful senses. The STEM Kit also allows SVI to individually solve mathematical questions, plot graphs etc. without interference, which allows them to be ‘do-ers’ in this regard.

The STEM Kit has been tested with secondary school level, mathematics but by extension from the questions solved, one could propose that it should be tested for solving more advanced mathematics. There is likelihood of it supporting other approaches, including the use of audio technology or human readers (Rowlett and Rowlett, 2009), and the complexity of converting or using electronic formats such as LaTeX and MathML (Cliffe 2009). The visual aspects of the presentation are removed when equations are typset with LaTeX. Presenting the information in LaTeX in a format (human readable) that can be readily understood by learners is still a challenge (Williams and Irving, 2012). Although MathML was designed for machine to machine communications of mathematics, it can help users to access mathematics electronically, but it is not well known. However, this is beyond the scope of this study.

Having said all the above, I will propose that learners should use the electronic solutions for areas that fit, and use the STEM Kit for areas that cannot be understood unless there is independent engagement.

The call to researchers for evidence-based study of teaching practices is also considered a key contribution of this study. The STEM Kit and the TLQ were evaluated in the two schools. From the findings, the resources had an impact on the learning of the SVI, irrespective of their previous experience with mathematics. It also had similar influence on sighted classmates in the two schools.

Another key contribution of this study is the fact that of all the studies explored in the literature review, none considered the impact of the resources on the sighted classmates in the mainstream schools. The focus always has been on how to include SVI in the subjects/curriculum. It is important to consider the broader class while seeking to include particular individuals, such that we would not be creating another problem when trying to solve one. This study however found that the sighted classmates were happy for the SVIs' engagement and participation. They were also not affected negatively, but they benefited from the extra time spent on tasks by the SVI.

The TLQ also offers a similar opportunity for both engagement and independence of the SVI in laboratory activities. Non-participation in laboratory activities cannot provide full access to the STEM curriculum. The laboratory work is an area people fear may expose the SVI to accidents and danger. Erwin et al. (2001) identify that taking risks is a key part of scientific discovery. There are different kinds of risks, some are acceptable and some are not. Similarly, Gary Vermeiji expressed on the type of risks he experienced in this quotation:

> *… there is nothing about my job that makes it unsuitable for a blind person. Of course, there are inherent risks in the field work; I have been stung by rays, bitten by crabs, and detained by police who mistook my partner and me for operatives trying to overthrow the government of their African country, and I have slipped on rocks, scraped my hand on sharp oysters and pinnacles of coral, and suffered from stomach cramps. There isn't a field scientist alive or dead who hasn't had similar experiences. Life without risk is life without challenge; one cannot hope to understand nature without experiencing it first-hand. The blind, no more than the sighted, must act sensibly and with appropriate caution. Along with independence comes the responsibility of assuming risks.*

Gary Vermeiji felt the risk is worth taking "it's the same to me as taking risks in the field, if one is collecting or observing marine life in what is ultimately a very dangerous place. If you don't take academic or intellectual risks, you're not going to be very interesting"

Furthermore, one of the conditions of learning listed by Cambourne is "approximation", which he explained as giving SVI opportunity to make mistakes (Cambourne 1988). Erwin et al. (2001) observed in their study that the SVI were enthusiastic, persistent in their investigations, developed positive relationships with peers, used scientific language and made connections between their studies and the real world when they took part in activities outlined in the curriculum

With the TLQ, recording of the readings on paper like the sighted is not necessary, since data could be stored for later use. The same TLQ can be used by different students, once the readings are properly saved, and recalling the information is easy. Having immediate interaction with the readings is also possible through the *analyse* menu in the TLQ; graphs can be plotted and be sent to the printer to be submitted to a sighted teacher. There is no need for the TVI to translate or convert from one format to another. The findings of this study agreed with the developers claim that TLQ enabled SVI to independently perform laboratory or field experiments successfully. However, this study is limited to the temperature probe and the pH sensor with the TLQ. There is need for further research on the TLQ and remaining available sensors. In the Nigerian context, where the TLQ is not in use for sighted students like in the USA, I will recommend to government to provide TLQ for SVI in mainstream schools, and the LabQuest without talking software for sighted in those schools, and possible extension to other schools. The practice is also not consistent within USA, nor in the UK. There is need for further research on which resources or practice produce best results, in order to serve as a leading example for schools/countries to emulate.

8.5.2. The findings in relation to ECC

The findings of this study suggest that possession of some ECC skills is needed for accessing science and mathematics, while inclusion in science and mathematics also strengthens or improves the ECC skills possessed by individual SVI. In this study, the STEM Kit was readily used, because the SVI had some compensatory skills (braille and tactile skills). Tinu and Sade displayed Career

Education and self-determination skills in their choice to shift from Arts to Science classes for the period of this study. Likewise, the readiness of SVI in study school 2 (who were not taught mathematics before) to agree to learn mathematics shows some idea of career education and self-determination.

The proficiency achieved after several uses of the resources also suggests that the SVI in both study schools have gained improved ECC skills.

As indicated in the theoretical framework, among Camborne's conditions of learning is "responsibility", which he explained as giving SVI the opportunity to make choices, because their non-inclusion in mathematics or sciences might limit their choice of career or eventually hinder success in their learning as they are not likely to be admitted to the University without a credit in SSCE mathematics.

The findings also highlighted the weaknesses of the two resources. This has implications for the designer of the STEM Kit and the producer of the TLQ. These have already been highlighted in the previous sections.

8.6. Implications of the findings for policy and practice

This section presents the implications of the findings from this study:

- to SVI in study schools,
- to SVI in other schools,
- to the teacher training institutions,
- to the Nigerian government.
- to the service providers. And
- For me as an action researcher

8.6.1. SVI in study schools

The findings have implications for SVI in the study schools, as the major beneficiaries of the study. They should build on the skills learnt from the study. They should learn about the UEB with which the STEM Kit is designed, and thereby practice more with the Kit such that they become familiar with arrangement and alignment of the tiles while working on the metallic board. This will make the lessons less stressful and possibly encourage the teachers. They should also practice more with the TLQ, such that all the facilities it offers can be fully used to enhance their full inclusion in science and mathematics lessons. In addition, they would develop their ECC skills, which might in turn enhance their independence.

For these to be achieved, both short term and long term arrangements were made. It was arranged that one of the research assistants should visit the study schools once a week, as a short term measure to sustain the change that was achieved during the research. As a long term arrangement, an NGO was registered with the Nigerian government (see Appendix VII for the certificate of incorporation), to further the recommendations of this study, and more. One of the programmes/visions of the NGO is to raise funds to produce the STEM Kit and other resources for distribution to SVI, starting from the study schools, such that the change achieved could be sustained. This would be extended to other mainstream schools across Nigeria, because the response of the government cannot be guaranteed. The skills learnt might have been forgotten before any response will be received by the schools.

8.6.2. SVI in other schools

The findings also have implications for SVI in other schools within and outside Nigeria. Since the time of the search conferences I have been receiving calls from SVI, teachers, and in some cases directors of special education in the other states not covered by this study. They requested that the effort should be extended to their state. This would be included in the activities of the NGO.

8.6.3. The teacher training institutions

The findings also have implications for teacher training colleges and special education faculties in Nigerian universities. The general colleges of education should include modules on Special Needs Education in the general education curriculum. The module should focus on specific needs of the different needs of special students. The Federal College of Education (Special) Oyo, where I am an academic staff member, needs to include specific modules on resources and strategies of teaching mathematics and sciences to SVI. There is also a need for collaboration among academic staff across departments in the college to develop and co-teach the module. It will require inputs from the Department of Visual Impairment Education, and each department in the School of Science because neither department can handle the module alone. There is a need for collaboration as suggested in the findings of Penrod, Haley and Matheson (2005). Such will improve scientific knowledge of one group and understanding of visual impairment of the other, which could lead to development of strategies of adapting resources that are to be passed on to the students undergoing training. There is also a need for organising short in-service courses for the teachers and TVI already working in mainstream schools. The government should be encouraged to sponsor the teachers for this training as a matter of urgency. The same is recommended for Special Education faculties in Nigerian universities.

8.6.4. The Nigerian government

The implication of the findings of this study to the Nigerian government is to monitor the practice of the educational policies. The government should not just stop at making good policies, but they should ensure adequate provisions are made in mainstream schools to reflect the special nature. In this study, Fasho Model College tried, in terms of the physical facilities. But the staff (both TVI and the science teachers) need to attend relevant training to support the facilities, because though the facilities alone aided SVI in some areas of ECC (O & M, self-determination, some compensatory skills), the students remain partly or totally excluded from the science and mathematics lessons, and this is reflected in them not being present in final examinations.

The state government of study school 2 also needs to be aware of successes and effort in place by Fasho state government, so that they can improve the physical facilities and work towards including the SVI in mathematics and science subjects, because as highlighted in the literature it is the right of all SVI to be given relevant and appropriate education.

There is also need for immediate emphasis on action, and for sanctions on any school or state that fails to provide full inclusion for SVI in mathematics and science subjects.

8.6.5. The service providers/manufacturers

These findings also have implications for the service providers/manufacturers to look at ways of including/reviewing their products to allow immersion and engagement, and other conditions of learning listed by Cambourne. In the interim, the STEM Kit could be used together with the existing electronic products, such that when full engagement is required the STEM Kit will be used, and when storing solved tasks for future use it could be done electronically.

8.6.6. For me as an action researcher

Given the focus of my action research, removing the items from the school was painful to me, as well as to the SVI, their teachers and the heads of the junior and senior schools. The Principals requested the prices of the resources, and submitted a request for purchase to the government. With determination to sustain the change, and wary of the possibility of intellectual theft, I effected the suggestions of participants on the STEM Kit, applied for copyright approval for the Kit, and made it available for purchase by individuals or schools. Before obtaining copyright for the STEM Kit, I continued supporting the SVI with the Kit and TLQ, as the research assistants used during the research were assigned to visit the school every week to maintain and improve on the success achieved with the resources.

8.7. Dissemination of the findings, and taking the work forward

In the Nigerian context, where not all SVI have access to a computer, the STEM Kit would provide an alternative way of including the SVI in mathematics and science subjects. The findings of this study should be disseminated, because the AR approach adopted requires continuity and implementation of the findings. It was in the plan to reorganise the search conferences to give feedback on the study to the participants. But partly because requests for conferences came from other states, and partly because we recognise the limitations of AR as regards implementation of findings by government part of the stakeholders that shared the same vision with me suggested forming a non-governmental organisation (NGO) to further the research, and see to how relevant resources can be available to the SVI. The approved name of the association is “Science and Technology for Nigeria Persons with Special Needs Initiative” (CAC/IT/NO 81291). The NGO is currently planning an International Conference in Abuja, Nigeria, because we have taken into consideration what it took to organise the last six search conferences, and the messages received from SVI in some other parts of Nigeria requesting that the research be extended to their state. It is believed that the conference will have a wider coverage, and there will be workshops mainly for teachers during the conference. The website of the NGO is www.scitec4sen.com

The NGO is also raising funds for producing STEM Kits to be distributed to SVI in the study schools, and by extension other schools mainstreaming SVI in other parts of the country. This we believe will support the government’s effort to sustain the change achieved by this study. We plan to submit proposals to grant agencies to widen the impact of the resources on the access of SVI to science and mathematics.

A proposal has been submitted to the National Research Fund (NRF) of the Tertiary Education Trust Fund (TETFUND), the Nigerian government agency responsible for providing funding for staff training and research for lecturers in our tertiary institutions (link http://www.tetfund.gov.ng/index.php/n-m/news/242-tetfund-national-research-fund-call-for-proposals.http://www.tetfund.gov.ng/inx.php/n-m/news/242-tetfund-national-research-fund-call-for-proposals.)

8.8. Methodological considerations

This part of the chapter discusses the methodological considerations involved in this research, because methodology occupies a central position in research. The design and methods adopted are appraised bringing out the strengths, and concluding with some identified limitations of the study.

The research as a whole from the initial aims suggests that a multi-design and multi-methods approach was needed. The exploratory study adopted a survey design and telephone interviews and a postal questionnaire as methods. The strengths and weaknesses are rightly presented in Chapter 3 (most notably the relatively poor response rate and lack of detailed responses).

The main design considered for evaluating the science teaching resources arose from the need to emancipate SVI, and possibly propose a change in the way science and mathematics is addressed in mainstream schools in South-Western Nigeria. The design was adopted considering my view of knowledge and what can be obtained. This was discussed at length in Chapter 4. A critical paradigm like interpretivism requires closeness to the participants. In fact, research needed to be conducted in collaboration, with participants as co-researchers – but this study goes further, focusing on change/emancipation, from denial of rights of SVI to equal educational opportunity. As explained earlier, my initial plan was to use RCT which some researchers considered the best approach for evaluating resources or strategies. However, it was considered that the study might not achieve this level of success, because of limited involvement of participants in RCT, the difficulty of controlling intervening variables with human participants, and the usefulness/implementation of the results of the research. The shift from RCT to AR has given me personal development in research. Teachers and practitioners are supposed to be involved in a great deal of action research for classroom and school improvement. The AR enabled me to work with the schools in a far more dynamic way that a more tightly structured experimental / evaluation framework would have allowed. As a result, the schools took real interest, responsibility and ownership of the problem and the solution. I am rightly hopeful that the work will be used for developing science education more broadly (the evidence and argument presented in this thesis are positively convincing), It is quite certain that the thesis has positively affected the education of the SVI and other children participating in these studies, and the two schools have a lasting legacy of change.

The suggestions or context of the participants shaped some decisions in this study in several ways:

1. The search conferences that were organised made me become more stakeholder focused.
2. Inclusion of mathematics in the study was influenced by participation of stakeholders at the search conference.
3. The choice of the SVI participants in Study Schools 1 and 2 was not as planned.

4. The design of the STEM Kit was influenced by initial interaction with the stakeholders (during the search conference).
5. Format of dissemination of the findings was also influenced by the co-researchers.

Below are some of the possibilities of the design and the methods adopted.

8.8.1. Design

A major possibility of the design adopted is contained in the change it proposed. Because the stakeholders were part of the study, there is a likelihood of the findings being considered for implementation, especially in the two study schools. Another key strength of AR is the beauty of the “search conference”. Not all researchers who adopted AR organise search conferences, but the success of this study can be partly attributed to the success of the search conferences held with stakeholders.

8.8.2. Methods

The three methods adopted for collecting data have peculiar strengths and weaknesses, which have been addressed in Chapter 4. However,in this study, the following are specific considerations. For email interviews, the specific strength is that they require no transcription and further confirmation from participants. The response rate was also very high as all the teachers involved in the study responded to the email. And for the focus group discussions, cross-checking the data with other participants was not needed, as the discussion was in a group, and they have the opportunity of seeing the transcripts of the discussion to affirm the correctness of the scripts. The observation gave room for non-spoken data to be collected, which was not possible with email interviews, and observation overcame some aspects of social desirability linked to indirect methods (interviews and focus groups). In all, it was possible to cross reference findings from the three methods of data collection.

8.9. Limitations of the study

All designs and methods have their peculiar strengths and weaknesses; this study is no different. The qualitative nature of the study will make it face criticism based on generalisability. However, details of the procedure are provided to enable replicability in similar contexts. As highlighted in Chapter 4, the yardstick for measuring the quality of qualitative research is not generalisability, and I have tried to put in place required measures to prove the validity and reliability of the findings. However, the influence of the researcher in interpreting the reports cannot be ruled out, especially since she was doubling as both designer and evaluator of the STEM Kit. The issue of steps taken to limit the influence was discussed in Chapter 4 under the heading *Researcher bias.*

Other limitations of the study are the limit of topics and the resources used. The resources have not been tested in advanced mathematics. Other components of the STEM Kit have not been evaluated, and the time only permitted evaluating the temperature probe and pH sensor with the TLQ. Further research is necessary to evaluate other components of the resources not covered in this study.

One of the limitations of this study is that the influence of the resources on specific ECC skills cannot be trailed from the start till the end of the study with the little exposure to the participants. Therefore, there is a need for a more in-depth study of the specific influence of the level of ECC possessed by SVI on the learning acquired, or rather to determine the specific improvement in the ECC skills that can be attributed to the use of the resources.

The complexity of my situation during this study, with inherent difficulties, financial and personal trauma and frustrations also has its contribution. However, the end justifies the means. Furthermore, the challenge of taking Western literature/resources and applying them in a context with a different culture also posed some inherent limitations.

8.10. Recommendations for further research

By virtue of the nature of the study and the limitations highlighted above, it is not possible to statistically generalise the findings. However, I can argue with some confidence that this work is relevant to other schools like this in Nigeria, and elsewhere. The study has achieved the aim of proposing a change to the access to science and mathematics of SVI in mainstream schools, through introducing and evaluating teaching resources. Replicability is possible, and this is one of the concerns of studies like this. That is why detailed information was provided

At some points in my discussion of results I identified areas that need further research. These are presented below in more specific terms.

The TLQ can be used with more than 70 sensors and probes. This study only evaluated the temperature probe and pH sensor. Further research is needed to ascertain the functionality of the resources in different countries with different educational contexts.

Similarly, the STEM Kit has other components, but because of the time available for this study, and with the agreement of the co-researchers, only the metallic board, adapted graph sheet and a few tiles were evaluated. There is a need for further research on the other components. There is also a need for evaluating it in developed countries, since it was established in the literature that the electronic solutions available cannot be used to teach all aspects of mathematics. The Cambourne model of learning also stresses the importance of hands-on experience in learning. Lewis and Allman (2014) have said that if a child’s hand is not involved, learning may not be happening. The STEM Kit offers an opportunity for the SVI to experience all the Cambourne conditions of learning.

There is need for replication of the study in other mainstream schools in Nigeria. And in agreement with recommendations of other research, there is need for evaluation of the various good practice advice abundantly available in the literature.

I also wish to recommend that the service providers should sponsor evaluation of their products, such that research evaluation of their suitability will be available in the literature. This would guide practitioners in their recommendations of suitable ones in particular contexts. For instance, if individual trained teachers, driving through change locally, have some attractive materials and technology to help sell the inclusive practice they are trying to promote, this would be a good idea and would bring their products to users, which in turn might bring about acceptance by stakeholders responsible for the purchase of resources. They will also have regular comments/appraisals from users, which will be better than simply thinking of, and producing, what they feel will be of use to SVI.

8.11. Conclusion

In conclusion, the study presented in this thesis focuses on improving access of mathematics and science to SVI in Nigeria. At the beginning, an exploratory study was conducted to confirm the problem of access by consulting some SVI and science teachers. The findings confirmed the problem: the unavailability of relevant resources and inadequate support were key reasons identified for the problem of access. A literature search revealed the existence of potential educational resources and strategies to improve access. This led to the selection of the TLQ, and the adoption of AR approach.

The first stage of AR involved the consultation with stakeholders through six search conferences. Reflections on the findings of the conferences led to the design of the STEM Kit, which could be used in conjunction with the TLQ which is most useful for laboratory and field activities. Both were then evaluated in two study schools. The findings indicated that the STEM Kit and TLQ were useful to SVI because they enabled independent access to the curriculum, leading to SVI engagement and equity with their classmates.

I wish to emphasise that my role in this thesis was not as a traditional “researcher”, but it was as a practitioner / advocate who identified and procured educational resources, equipment and training to bring about change. As a researcher, I tried to systematically record and describe this and this was undoubtedly challenging. Furthermore, my job as a researcher, attempting to connect the broader abstract ideas – the theory – was also challenging. Nevertheless, my journey from a practitioner concerned that students were not taking science and mathematics has been transformed, to now having a greater understanding of inclusive education and the connections this has with ECC and independence.

The interventions (i.e. the introduced educational resources, equipment and training) enhanced SVI inclusion – using the language offered by Cambourne, the interventions enhanced SVI *immersion* in classroom activities, allows *demonstration* of what was learnt, and enhanced overall student *engagement* in the classroom. This is reflected in the graph plotting task in study school 1, in which all SVI were successfully included.

Similarly, sighted teachers were able to use the STEM KIT during the lessons which enabled all SVI to be engaged like their sighted peers. SVI also participated independently and actively in practical activities with the TLQ. This implies that the intervention enabled the ‘conditions of learning’ to be fulfilled for these learners as described in Cambourne’s learning theory: the SVI were transformed from “done-to-ers” and became “do-ers”.

Similarly, the educational resources also influenced some aspects of the expanded core curriculum (ECC) acquired or possessed by the SVI. For example, opportunities for social interaction skills to be developed through studying *together* with sighted peers (e.g. using the STEM Kit meant the sighted could read the print and SVI could read the braille on the tiles *together*). The SVI also displayed good self-determination skills with the enthusiasm with which they attended the classes, not minding their previous negative experience (such as being presented inaccessible mathematical materials and diagrams). The improved engagement with the resources suggests an improvement in assistive technology skills. Successful participation in practical activities with the TLQ equipment improves in sensory efficiency skills (e.g. listening to voiced data). Similarly, tactile recognition of braille on the tiles also shows improvement in sensory efficiency skills (e.g. tactile recognition).

Overall, all these opportunities for communication between SVI, sighted peers and their teachers indicate that the study interventions brought about improved independent access to the curriculum for all, and a more inclusive classroom and school.

LIST OF REFERENCES

Abdullah, M. Y, Abubakar, N. R and Mahbob, M. H. (2012) 'The dynamics of student participation in classroom: observation on level and forms of participation' *Procedia - Social and Behavioral Sciences* 59, 61-70.

Abilu, R. A. (2005) *An Evaluation of Science Education of Secondary School Students with Visual Impairment* Unpublished M.Ed Dissertation Nigeria: University of Ibadan.

Abilu, R. A. (2012) 'Teaching Science and Mathematics to Learners with visual impairment in Nigeria: a perspective' *The Journal of Advocacy and Rehabilitation in Special Education (JARSE)* 11(1):78-82.

Abiose, A., Murdoch, I. 0., Babalola, S., Cousens, I., Liman, J., Onyema, J. W., Gregory, E. and Jones, B. (1994) 'Distribution and aetiology of blindness and visual impairment in mesoendemic onchocercal communities, Kaduna State, Nigeria' *British Journal of Ophthalmology*; 78:8-13.

Abosi C.O. and Ozoji E.D. (1985) *Educating the Blind. A descriptive approach.* Ibadan: Spectrum.

Achor, E. E. and Orji, A. C. (2009) 'Level of students' motivation in classroom interactions in Integrated Science' *Journal of Research in Curriculum and Teaching* 4 (1):294-303.

Adaka, T. A. (2010) 'Including the excluded: A key to the attainment of the MDGs' *The Exceptional Child* 12(1):254-265.

Adebimpe, O. A., Imam, A. O., Akinlubi, I. S et al. (2014) **'**Availability and accessibility of information materials for sustainable academic achievement of the visually impaired persons at Sped, Oyo *Journal of Issues in Special Education* 13(2), http://www.fcesjisse.edu.ng/ArticleDetails.aspx?id=51001 Accessed on 15th, January, 2016

Adebisi, R. O., Jerry, J. E., Rasaki, S. A. et al. (2014) 'Barriers to special needs education in Nigeria' *International Journal of Education and Research* 2(11):451-462.

Adediran, O. A. and Oluokun, A. A. (2007) 'The need for visually impaired students' participation in science education: Its implication for counselling' *International Journal of Emotional Psychology and Sport Ethics (IJEPSE)* 9 (June):73-80.

Adelakun S. A. (2014) 'Expanded Core Curriculum' *Paper presented at the AERBVI International Conference, San Antonio Texas* July 30 -August 3, 2014

Adelakun, S. A (2013b) 'Inspirations from Scientists and Engineers Who Are Blind and Visually Impaired - Lessons to Initiate New Direction for Science Education of Blind Students in Nigeria' *Conference proceedings. International Conference new perspectives in science education* ISBN code (978-88-6292-351-4) Libreriauniversitaria.it. Edizioni,

Adelakun, S. A. (2006) 'Effects of Using Tactile Models on the Academic Performance of Visually Impaired Junior Secondary Students in Selected Chemistry Topics in Integrated Science' *Unpublished M.Ed Dissertation* Nigeria:University of Ilorin.

Adelakun, S. A. (2003) 'Issues in Science Education for the Visually Impaired' in W.O. Fatokun, O. A. Adebimpe, O.K. Omoniyi and T. Ajobiewe (Eds) *Science and Technology in Special Education* Oyo: SPED Publications.

Adelakun, S. A.(1998) 'The Relevance Of Scientific Skills And Attitudes In The Education of the Visually Impaired' *Ilorin Journal of Education* 18:35-39

Adelakun, S. A. (1997) 'Gaming in integrated science class' *Paper 38 Science Teachers Association of Nigeria (STAN), Annual Conference Proceedings:* 209 – 211.

Adelakun, S. A. (1994**)** 'Effect of using adapted materials in teaching science to the visually impaired' *Journal of issues in Special Education* 2(2) 105-109.

Adelakun, S. A. Ogunyemi, A. O., and Akinyode, J. A. (2007) 'Effect of Games as a Pedagogical Approach on the Academic Performance of Junior Secondary Visually Impaired Students in Integrated Science' *Journal of International Council of Health, Physical Education, Recreation, Sport and Dance, 2*(2):106-109.

Adeniji, M. A. and Babalola, G. A. (2015) 'Learning resources for the education of the blind in Nigeria' *Academic Librarianship and Manpower Development* https://www.academia.edu/3820777/learning_resources_for_the_education_of_the_blind_in_nigeria Date accessed: 20th August, 2015

Adler, P. A. and Adler, P. (1994) 'Observational Technique' in N. Denzin and Y. Lincoln (Eds) *Handbook of Qualitative Research*, London: SAGE Publications:377-391.

Aduwa-Ogiegbaen, S. E., and Iyamu, E. O. S. (2005) 'Using Information and Communication Technology in Secondary Schools in Nigeria: Problems '*Educational Technology and Society* 8(1): 104-112.

Agunloye, O.O., Pollingue, A.B., Davou, P. and Osagie, R. (2011) 'Policy and Practice of Special Education: Lessons and Implications for Education Administration from Two Countries' *International Journal of Humanities and Social Science* 1(9):90-95.

Ajaiyeoba, A.I., Isawumi, M.A., Adeoye, A.O. & Oluleye, T.S. (2006) ‘Prevalence and Causes of Eye Diseases Amongst Students in South-western Nigeria’ *Annals of African Medicine* (5):197-203.

Ajuwon, P. M. (2008)’Inclusive Education for Students with Disabilities in Nigeria: Benefits, Challenges and Policy Implications’ *International Journal of Special Education*, 11-17

Akale, M. A. G. and Nwankwonta, N. A. (1996) ‘A study of Students’ and Teachers Perceptions of Laboratory/Classroom Environment in Secondary Science Schools *Journal of Science Teachers Association of Nigeria* 31(1 & 2):15-22.

Akanji, D. O. (2009) *A Study of Blind Education in Three States of Nigeria* Victoria: Trafford Publishing.

Aladeselu, N. I. (2010) ‘Council for Education in the Commonwealth Nigeria: 50 years of progress and challenges in the education Sector’ Lecture delivered to commemorate Nigeria 50 years in the Commonwealth at the Palace of Westminster, London London and the University of Sussex: The Consortium for Research on Educational Access, Transitions and Equity, Institute of Education. 8th December, 2010.

Alexander, R. J. (2008). Education for All, The Quality Imperative and the Problem of Pedagogy. Brighton: Consortium for Research on Educational Access, Transitions and Equity

Allman, C. B and Lewis, S. (2014) ‘A Strong Foundation: The Importance of the Expanded Core Curriculum’ in C.B. Allman and S. Lewis (Eds)*ECC Essentials Teaching the Expanded Core Curriculum to Students with Visual Impairments*. New York:AFB Press: 15- 29.

Alonzo, L. (1986) ‘Reflections on transition’ *Journal of Visual Impairment and Blindness*80: 979-984.

Anaduaka, U. S. and Okafor, C. F. (2013) ‘The Universal Basic Education (UBE) Programme in Nigeria: Problems and Prospects’ *Basic Research Journal of Educational Research and Review* 2(3):42-48.

Angrosino, M. V.,and Mays de Pérez, K. A. (2002) ‘Rethinking Observation: from method to context’ in N. K. Denzin and Y. S. Lincoln (eds) *Handbook of Qualitative Research (Second Edition*). Thousand Oaks: Sage:

Anjiode, K. J. (2010) ‘Information Resources and Services to Physically Challenged in Plateau State Special Educational Institutions’ *Samaru Journal of Information Studies* 10 (1 & 2):1-11.

Aromolaran E. (2005) ‘Training Special Educators for Low Vision Children in Nigerian Regular Schools *Journal of Science and Vocational Education*, 2 (2):53-56.

Aronson, S. H. and Sherwood, C. C. (1974) 'Researcher Versus Practitioner: problems in social action research' in C.H. Weiss(Ed) *Evaluate Action Programs* Boston: Allwyn and Bacon: 283-293.

Asghar, J. (2013) 'Critical Paradigm: A Preamble for Novice Researchers' *Life Science Journal* 10(4):3121-3127.

Atinmo, M.I. (2007) "Setting up a computerized catalog and distribution database of alternative format materials for blind and visually impaired persons in Nigeria", *Library Trends*, Vol. 55 No. 4, pp. 830-46.

Audu, T. A. and Achor, E. E. (2003) 'The Role of Questioning and Wait-time Interactional Process in Science Teaching and Learning' *Jos Journal of Education* 6 (2):65-69.

Ayoku, F. A. (1998). Science and Education for the visually Handicapped in Nigeria. *The Exceptional Child*. 2 (1) pp 38-40

Ayoku, F. A. (2006) 'The Visually Impaired in Regular Classroom' in T. C. Obani (Ed) *Teaching Pupils with Special Educational Needs in Regular UBE Classroom* Ibadan: Book Builders.

Azanor, V. O. (2014) 'A critic of inclusive educational programme in Nigeria JISSE' 13 (1) http://www.fcesjisse.edu.ng/ArticleDetails.aspx?id=36001 Accessed on 21 May, 2015

Beck-Winchatz, B.and Riccobono, M. A. (2008) 'Advancing Participation of Blind Students in Science, Technology, Engineering, and Mathematics' *Advances in Space Research* 42:1855-1858.

BERA (2011) *Ethical guidelines for educational research 2nd revision*. London: BERA.

Blankenship, K. (2007) 'Effective instruction in the expanded core curriculum' Paper presented at the preconference day-long presentation, Texas Focus, San Antonio.

Blankenship, K. (2008) 'Effective instruction in the expanded core curriculum' *Paper presented at the New Mexico AER Conference, Albuquerque on February 21st and 22nd, 2008*

Bogdan, R. C. and Biklen, S. K (1982) *Qualitative Research for Education: An introduction to Theory and Practice* Hemel Hempstead: Allwyn and Bacon.

Braimoh, D. S. and Okedeyi, A. S. (2001) 'Direction of professional development for classroom teachers in effective science, technology and mathematics teaching: Matters Arising' *Lagos Journal of Science Education* 5: 33-37.

Braun, V. and Clarke, V. (2006) ‘Using thematic analysis in psychology’ *Qualitative Research in Psychology* 3 (2):77-101.

Brock-Utne, B. and Holmarsdottir, H. (2004). Language policies and practices in Tanzania and South Africa: problems and challenges. International Journal of Educational Development, 24, 67–83.

Brydon-Miller, M., Greenwood, D. and Maguire, P. (2003) ‘Why Action Research?’ *Action Research*1 (1):9-28.

Bryman, A. (1988) *Quantity and Quality in Social Research*. London: Unwin Hyman.

Bryman, A. (2012) *Social Research Methods (4th edition)* Oxford:Oxford University Press.

Buhagiar, M. A. and Tanti, M. B. (2011) ‘Working Toward the Inclusion of Blind Students in Malta: the case of Mathematics classrooms’ *Journal of Theory and Practice in Education* 7 (1): 59-78.

Burke, E. A. (1932) ‘Laboratory Work in Science for the Blind’ *The Teachers Forum* 4: 48-49.

Bybee, R. W. (1997) *Achieving Scientific Literacy: from purposes to practical action* Portsmouth, NH: Heinemann.

Cambourne, B. (1988) *The Whole Story: natural learning and the acquisition of literacy in the classroom* Auckland: Ashton Scholastic, Inc.

Cambourne, B. (1995) ‘Toward an educationally relevant theory of literacy learning: twenty years of inquiry’ *The Reading Teacher* 49(3):182-190.

Cartwright, N. (2010) ‘What are Randomised Controlled Trials Good For?’ *Philosophical Studies* 147(1):59-70.

Cetera, M. M. (1983) ‘Laboratory Adaptations for Visually Impaired Students. thirty years in review’ *Journal of College Science Teaching* 12 384-393.

Clay, R. A. (2010) ‘More than one way to measure’ *Monitor on Psychology* 41(8) 52

Cliffe, E. (2009) ‘Accessibility of Mathematical Resources: the technology gap’ *MSOR Connections* 9 (4): 37-42.

Cohen, L. and Manion, L. (2007) *Research Methods in Education* London: Sage Publications

Corbin, J., and Strauss, A. (2008) *Basics of qualitative research* (3rd ed). Thousand Oaks, CA: Sage

Coughlan, P. and Coglan, D. (2002) 'Action Research for Operations Management *International Journal of Operation and Production* Management 22 (2): 220-240.

Coville, M. G. (1932) 'Content of a Course in General Science: Adapted for use with the Blind' in *Proceedings of 31st Biennial Convention of the American Association of Instructors of the Blind* pp 773-775

Cox, P. R. and Dykes, M. K. (2001) 'Effective Classroom Adaptations for Students with Visual Impairments' *Teaching Exceptional Children* 33(6):68-74.

Creswell, J. W. (2007*) Qualitative inquiry and research design: Choosing among five approaches (2nd ed.)* Thousand Oaks, CA: Sage.

Cryer, H. (2013) *Teaching STEM Subjects to Blind and Partially Sighted students: literature review and resources* Birmingham: RNIB Centre for Accessible Information (CAI).

Cryer, H. and Gunn, D. (2008) *Exploring Tactile Graphics* Birmingham: RNIB Centre for Accessible Information.

Curasi, C.F. (2001) 'A Critical Exploration of Face-to-face Interviewing vs. Computer-Mediated interviewing *International Journal of Market Research* 43(4): 361–375

Curry S.A and Hatlen P.H (2007) 'Meeting the Unique Educational Needs of Visually Impaired Pupils Through Appropriate Placement' *Journal of Visual Impairment and Blindness,* http://www.eccadvocacy.org/section.aspx?TopicID=451&DocumentID=5282 *accessed 15th March, 2014.*

David, M. and Sutton, C. D. (2011) *Social Research: An Introduction* London: Sage.

Davis, P. and Hopwood, V. (2001) *Teaching Children with Visual Impairment in the Mainstream Primary School* Manchester: University of Manchester.

Denscombe, M. (2003) *The Good Research Guide***.** Maidenhead: Open University Press

Denzin, N. (1970) *The Research Act in Sociology*, Chicago: Aldine

Denzin, N.K. (1978) *Sociological Methods* New York: McGraw-Hill.

Dewey, J. (1916) *Democracy and Education* New York: Macmillan.

Dommeyer, C.J., and Moriarty, E. (2000) 'Comparing two forms of an e-mail survey: Embedded vs. attached' *International Journal of Market Research* 42(1): 39–50.

Douglas, G and McLinden, M (2005) 'Visual Impairment' in A. Lewis and B. Norwich (Eds.) *Special Teaching for Special Children: pedagogies for inclusion* pp. 26-40 Maidenhead:Open University Press.

Douglas, G., McLinden, M., McCall, S., Pavey, S., Ware, J., and Farrell, A. (2011) 'Access to print literacy for children and young people with visual impairment: findings from a review of literature *European Journal of Special Needs Education*. 26(1), 25-28

Douglas, G., Pavey, S., Corcoran, C. and Clements, B. (2012) 'Evaluating the use of the ICF as a framework for interviewing people with a visual impairment about their mobility and travel' *British Journal of Visual Impairment* 30(1):6–21.

Dowling, P. C. (1998) *The sociology of mathematics education: Mathematical myths/pedagogic texts*. London: Falmer Press.

Duggan, S. and Gott, R. (2002) 'What Sort of Science Education do we really need?' *International Journal of Science Education* 24: 661-679.

Duit, R. (1996) 'The Constructivist View in Science Education – what it has to offer and what should not be expected from it' *Investigações em Ensino de Ciências* V1(1):40-75.

Dunn, J. and Meredith, L. (2004) *Working with Disabled Students: teaching a physics laboratory module to blind students*http://www.nottingham.ac.uk/pesl/resources/disability/teaching102/ Accessed 4th February,2013

Eichenberger, R. J. (1974) 'Teaching Science to the Blind Student' *Science Teacher*41(9): 53-54.

Eneh, O. C. (2011) 'Nigeria's Vision 20:2020 –issues, challenges and implications for development Management' *Asian Journal of Rural Development*1: 21-40.

Enitan, O. O. (2009) *Towards Providing Inclusive Education for School Aged Visually Impaired Children in Nigeria: The Ijanikin Experience* http://icevi.org/publications/icevi_wc2006/09_inclusive_educational_practices/Papers/afr_042_enitan.pdf. Accessed 4th March,2013

Eriba, J. O. and Achor, E. E. (2010) 'Effects of School Type and Teacher Gender on Classroom Interaction Patterns in Integrated Science Classes' *Brunei International Journal of Science and Mathematics Education,* 2(1):45-58.

Erwin, E.J., Perkins, T.S., Ayala, J., Fine, M. and Rubin, E. (2001) ' "You don't have to be sighted to be a Scientist, do you?" Issues and outcomes in science education' *Journal of Visual Impairment and Blindness* 95(6): 338-352.

Etter, J.F. and Perneger, T.V. (2001) 'A comparison of a Cigarette Smokers Recruited Through the Internet or by Mail *International Epidemiological Association 30*: 521-525.

Expanded Core Curriculum – NCAER

Ezegwui, I. R., Umeh, R. E. and Ezepue, U. F. (2003) 'Causes of Childhood Blindness: results from schools for the blind in south eastern Nigeria *British Journal Ophthalmology* 87:20-23.

Fabunmi, M. (2005) 'Historical Analysis of Educational Policy Formulation in Nigeria: Implications for Educational Planning and Policy' *International Journal of African and African American Studies* 4 (2):1-7

Fazzi, D. L. (2014) 'Orientation and Mobility' in C.B. Allman. and S. Lewis (Eds) *ECC Essentials: Teaching the Expanded Core Curriculum to Students with Visual Impairments* New York: AFB Press: 248-282.

Fazzi, D. L. and Naimy, B. J. (2010)' Teaching Orientation and Mobility to School-age Children' in W. R. Wiener, R. L. Weish, and B. B. Blasch (Eds) *Foundations of Orientation and Mobility: Vol II. Instructional strategies and practical applications* (3rd edition) New York: AFB Press :208-263..

Fazzi, D. L., and Petersmeyer, B. A. (2001) *Imagining the Possibilities: creative approaches to orientation and mobility instruction for persons who are visually impaired* New York: AFB Press.

Federal Government of Nigeria (2010) *Nigeria Vision 20:2020: The First National Implemen*tation Plan (2010 – 2013). Volume II: Sectoral Plans and Programmes. May 2010 https://ims.undg.org/downloadFile/64968927584323 accessed 2nd January 2011

Federal Ministry of Education (2009) Approved National Strategy for the Education of persons with special needs. FME Special Education SP/NDS/E/01 Lagos: NERDC Press.

Federal Republic of Nigeria (1977) *National Policy on Education* (3rd edition). Lagos: NERDC Press.

Federal Republic of Nigeria (1981) *National Policy on Education* (3rd edition). Lagos: NERDC Press**.**

Federal Republic of Nigeria (1989) "*National Policy on Education"* (3rd edition). Lagos: NERDC Press.

Federal Republic of Nigeria (2004) *National Policy on Education* (4th edition). Lagos: NERDC Press.

Federal Republic of Nigeria (2008) *National Policy on Education* (5th edition) Lagos: NERDC Press.

Ferrell, K. A. (2011) *Reach out and teach: helping your child who is visually impaired learn and grow* New York: AFB Press.

Ferrell, K. A., Buettel, M., Sebald, A. M. and Pearson, R. (2006) Mathematics research analysis Louisville, KY: American Printing House for the Blind.

Fletcher, E. (2011) 'Student has no trouble visualising a Doctorate in Chemistry' *The Braille Monitor* 54 (10). [Open access journal; no page numbers]

Fraser, K (2008) 'Oceanography for the Visually Impaired' *The Science Teacher* 75 :28-32.

Fraser, W. J. and Maguvhe, M. O. (2008) 'Teaching Life Sciences to Blind and Visually Impaired Learners *Journal of Biological Education* 42(2), 84-89.

Freire, P. (1972) Pedagogy of the Oppressed. London: Penguin

French, R. S. (1924) 'A Necessary Factor in a Modern Curriculum' in *Proceedings of the 27th Biennial Convention of the American Association of Instructors of the Blind*:152-154 held between November 11-12, 1924

Garuba, A. (2003) 'Inclusive Education in the 21st Century: challenges and opportunities for Nigeria' *Asia Pacific Disability Rehabilitation Journal* 14 (2): 191-200.

Gibson, C. A. (1932) 'The Value of General Science to the Blind Child' In *Proceedings of the 31st Biennial Convention of the American Association of Instructors of the Blind* :771-773.

Giwa, O.Y. and Ogunkunle, S.J. (2004) 'Preliminary NCE Curricular Reforms for Qualitative Science Education of Children with Disabilities at the Primary School' in T.A Adedoja and T. A. Ajobiewe (Eds) *Issues in Coping with Disabilities in Developing Countries* Oyo: SPED Publications. 230-235

Goldberg, R. T (1974) 'Rehabilitation Research: New Directions *Journal of Rehabilitations* 40(3)12-15.

Grix, J. (2004) *The Foundations of Research* London: Palgrave Macmillan.

Grundy, S. (1987) *Curriculum: product or praxis?* Lewes: Falmer Press

Gummesson, E. (2000) *Qualitative methods in Management Research* London: Sage.

Halfpenny, P. (1982) *Positivism and Sociology* London: Allen and Unwin.

Hall, A., Scholl, G.T., and Swallow, R. (1986) 'Psychoeducational Assessment' in G.T. Scholl (ed.) *Foundations of Education for Blind and Visually Handicapped Children and Youth: theory and practice.* New York: American Foundation for the Blind.

Hamilton, D. W. (1934) ‘What Science Teaching is Advisable in our High School Departments’ in *Proceedings of 32nd Biennial Convention of the American* Association of Instructors of the Blind:131-136.

Hammerserley, M. (2012) *Methodological Paradigms in Educational Research, BERA* t https://www.bera.ac.uk/researchers-resources/publications/methodological-paradigms-in-educational-research accessed 25th January 2016.

Hammersley, M. (2007) Methodological Paradigms in Educational Research London: TLRP

Hancock, B. (2002). *Trent focus group: An introduction to qualitative research*. Nottinghom: University of Notinghom.

Harrell, L. (1992) ‘Hospitalization Issues’ in R. L. Pogrund, D. L. Fazzi, and J. S. Lampert (Eds) *Early Focus: Working with young blind and visually impaired children and their families* New York: AFB Press. [Open access journal; no page numbers]

Harwood, J. (2007) *Understanding Communication and Aging*. Thousand Oaks: CA: Sage.

Hatlen, P. (1996) The Core Curriculum for Blind and Visually Impaired Students, Including those with Additional Disabilities *Review 28*: 25-32.

Hatlen, P. (2003) ‘Impact of Literacy on the Expanded Core Curriculum’ *Paper presented at the Getting in Touch with Literacy Conference,* Vancouver, British Columbia, Canada

Hegarty, S. Pocklington, K., and Lucas, D (1982) Educating pupils with special needs in the ordinary school. Windsor, Berkshire: NFER-Nelson

Hill, K. E. (1994) ‘Practical Science with visually Impaired Nigerian Students’ *British Journal of Visual Impairment* 12(1):37-40.

Hill, K. E. (1999) Problems Encountered by Visually Handicapped Nigeria Candidates in Schools and Public Examinations and some Strategies to Overcome Them’ *The Educator* **(**Winter edition)

Hill, K. E. and Jurmang I. (1996) ’Changing attitudes to blind students’ participation in Science, Technology and Mathematics (STM) classes 1980-1985’ in I. A. Nwazuoke I. A. and I.A. Kolo (Eds) *Exceptional Persons in the Community* NCEC: Ibadan.

Hobson, A.J. and Townsend, A.J. (2010) ‘Interviewing as Educational Research Method(s)in: D. Hartas (Ed.) *Educational Research and Inquiry*:223-238. London: Continuum.

Hodges, A. (2001) *Children's and Women's Rights in Nigeria: a wake up call. Situation assessment and analysis for 2001* Abuja: National Planning Commission and UNICEF.

Holsinger, D. B. and Cowell, R. N. (2000) *Positioning Secondary School Education in Developing Countries* Paris: International Institute for Educational Planning/UNESCO.

Huebner, K. M., Merk-Adams, B., Stryker, D. and Wolffe, K. E. (2004) *The National Agenda for the Education of Children and Youths with Visual Impairments, Including those with Multiple Disabilities* New York: AFB Press.

ILAB: Independent Laboratory Access for the Blind Home page. http://ilab.psu.edu/ accessed on 10th May 2012

Individuals with Disabilities Education Improvement Act of 2004, Pub. L. No. 108-446, 118 Stat. 2647 (2004) (amending 20 U.S.C. §§ 1400 *et seq.*) Accessed 17th June, 2014

Individuals with Disability Education Act Amendments of 1997 (IDEA) (1997) Retrieved from http://thomas.loc.gov/home/thomas.php. Accessed 10th February, 2012

Ivowi, U.M.O., Okebukola, P.A.O., Oludotun, J.S.O. and Akpan, B.B. (1992) *Raising Standard of Performance in Public Examinations in Science, Technology and Mathematics (No 4)* Lagos: Science Teachers Association of Nigeria

Jakob, A. (2001) 'On the Triangulation of Quantitative and Qualitative Data in Typological Social Research: Reflections on a Typology of Conceptualizing 'Uncertainty' in the Context of Employment Biographies' *Forum: Qualitative Social Research*2(1). **[**Open access journal; no page numbers]

Jones, M. G., Minogue, J., Oppewal, T., Cook, M. P. and Broadwell, B. (2006) 'Visualising without Vision at the Microscale: Students with visual impairments explore cells with touch *Journal of Science Education and Technology* 15 (5):345-351.

Kamberelis, G. and Dimitriadis G. (2012) *Evidence and Expertise in Education* New York: Routledge.

Kaur, S. (2013) 'Action Research in Education' *International Journal of Research Methodology* 3 (2):255-258.

Keeley-Browne, L (2014) *Achieving Your Award in Education and Training* Maidenhead: Open University Press.

Kemmis, S., and McTaggart, R. (1988) *The Action Research Planner (3rd edition*) Geelong, Victoria:Deakin University.

Kim, B.S.K., Brenner, B.R., Liang, C.T.H. and Asay, P.A. (2003) 'A Qualitative Study of Adaptation Experiences of 1.5-generation Asian Americans' *Cultural Diversity and Ethnic Minority Psychology* 9(2):156–170.

Kincheloe, J. L. and McLaren, P. (2000) 'Rethinking critical theory and qualitative research' in N. K. Denzin and Y. S. Lincoln (Eds.) *Handbook of Qualitative Research (2nd ed.)* Thousand Oaks: Sage: 279- 313)..

Kitzinger, J. (1994) 'The Methodology of Focus Groups: the importance of interaction between research participants *Sociology of Health and Illness* 16(1): 103-121.

Koenig, A. and Holbrook M.C. (2000) *Foundations of Education: History and Theory of Teaching Children and Youths with Visual Impairments, vol. 1, (2nd Edition)*, New York: American Foundation for the Blind.

Krane, V., Eklund, R. and McDermott, M. (1991) 'Collaborative Action Research and Behavioral Coaching Intervention: a case study *Applied Research in Coaching and Athletics Annual 6*:119-148.

Krizack, M. (2000) Making science accessible to blind students. *Disability World*, 3.

Krueger R. A. and Casey, M. A. (2009) *Focus Groups: A Practical Guide for Applied Research* London: Sage.

Kuhn, T.S. (1970) *The Structure of Scientific Revolutions. 2nd edition* Chicago, IL: University of Chicago Press.

Kumar, D. D., Ramasamy, R. and Stefanich, G. P. (2001) 'Science for Students with Visual Impairments: teaching suggestions and policy implications for secondary educators' *Electronic Journal of Science Education* 5 (3): [Open access journal; no page numbers]

Kyari, F., Gudlavalleti, M.V.S., Sivsubramaniam,S., Gilbert, C. E., Abdull, M. M., Entekume, G. andFoster, A. (2008) 'Prevalence of Blindness and Visual Impairment in Nigeria: The national blindness and visual impairment survey' *Investigative Ophthalmology and Visual Science*. 50(5): 2033-2039.

Lang, R. and Upah, L. (2008) Scoping Study: Disability issues in Nigeria *Final Report* London: DFID

Lewin, K. (1948) 'Resolving social conflicts; selected papers on group dynamics' New York: Harper & Row.

Lewis, S. and Allman, C. B (2014) 'Learning, Development and Children with Visual Impairments: The Evolution of Skills' in C. B. Allman. and S. Lewis (Eds) *ECC Essentials: Teaching the Expanded Core Curriculum to Students with Visual Impairments* New York: AFB Press:3-14.

Lindsay, D. S. (2007) ‘Autobiographical Memory, Eyewitness Reports, and Public Policy’ *Journal of Canadian Psychology* 48(2):57–66.

Lohmeier, K. L (2001) **‘**Aligning State Standards and the Expanded Core Curriculum: Balancing the Impact of the No Child Left Behind Act’ *Journal of Visual Impairment & Blindness* 103(1):44-47

Lohmeier, K. (2003) *Aligning the state standards and the expanded core curriculum* (rev.)http://www.ed.arizona.edu/azaer/AZ%20Standards%20Aligned.pdf. Accessed 21 June, 2014

Lohmeier, K. (2005) ‘Implementing the expanded core curriculum in specialized schools for the blind’ *Review* 37(3):126.

Lohmeier, K., Blankenship, K. and Hatlen, P. (2009) ‘Expanded Core Curriculum: 12 years later *Journal of Visual Impairment and Blindness* 103(2) 103-112.

Lowenfield, B. (1973) ‘Psychological Considerations’ in B. Lowenfield (Ed) *The Visually Handicapped Child in School* New York: John Day Co.27-66

Lunney, D. and Morrison, R. C. (1981) ‘High Technology Laboratory Aids for Visually Handicapped Chemistry Students’ *Journal of Chemical Education* 58: 228-231.

MacIsaac, D. (1995) An Introduction to Action Research’ http://www.phy.nau.edu/~danmac/actionrsch.html accessed 2nd April 2014’.

Mai, L. W. (2005) ‘A Comparative Study Between UK and US: The Student Satisfaction in Higher Education and its Influential Factors’ *Journal of Marketing Management* 21 (7-8):859-878.

Mario A. B.; MacEntee, M. I. and O’Connor, D. (2011). ‘Email as a Data Collection Tool When Interviewing Older Adults’ *International Journal of Qualitative Methods* 10 (3):221-230.

Mason, H. and McCall S. (1997) *Visual Impairment: Access to Education for Children and Young People* London: David Fulton Publishers.

Mason, J. (1996. *Qualitative Researching* London: Sage

Mason, J. (2002). *Qualitative Researching. 2nd Edition*. London: Sage.

McDonald, J. and Coghlan, D. (2001) ‘The Art of Clinical Inquiry in Information Technology Related Organizational Research’ in P. Reason and H. Bradbury, (Eds) *Handbook of Action Research* London: Sage:372-378.

McLinden, M. and Douglas, G. (2013) ‘Education of Children with Sensory Needs: reducing barriers to learning for children with visual impairment’ in A. Holliman (Ed) *Educational Psychology*: *an international perspective*. London: Routledge.

McNear, D., and Farrenkopf, C. (2014) ’Assistive Technology’ in C.B. Allman and S. Lewis(Eds) *ECC Essentials: Teaching the Expanded Core Curriculum to Students with Visual Impairments* New York: AFB Press: 187-247).

Meho, L. I. (2006) ‘E-Mail Interviewing in Qualitative Research: A methodological discussion’ *Journal of the American Society for Information Science and Technology,* 57 (10):1284-1295.

Mertler, C. A. (2014) ‘*Action Research: Improving schools and empowering educators 4th Edition London*: Sage.

Mertler, C. A. and Charles, C. M. (2011) ‘Experimental, Quasi-experimental, and Single-subject Designs *Introduction to Educational Research* Thousand Oaks, **CA**: SAGE 286-317.

Meyer J. (2000) Using qualitative methods in health related action research. BMJ. ;320,178-181.

Miles, M. B. and Huberman, A. M. (1994) *‘Qualitative Data Analysis: An expanded sourcebook (2nd ed.)* Thousand Oaks, CA: Sage.

Mills, G. E. (2011) *Action research: A guide for the teacher researcher* (4th ed.). Boston: Pearson.

Millward, L. J. (1995) ‘Focus groups *2*. in G.M. Breakwell, J.A. Smith and D.B. Wright, D. B. (Eds) *Research Methods in Psychology.* Los Angeles:Sage.

Miner, D., Nieman, R., Swanson, A. and Woods, M. (2001) *Teaching Chemistry to Students with Disabilities: A Manual for High Schools, Colleges, and Graduate Programs* Washington, D.C: American Chemical Society.

Moore N. (2000) *How To Do Research: The complete guide to designing and managing research project* London: Library Association Publishing.

Morris, K. (1981) *Mathematics and the Physical World* New York: Dover Publications Inc.

Morrison, R. and Lunney, D. (1984) ‘The Microcomputer as a Laboratory Aid for Visually Impaired Science Students’ *Journal of Visual Impairment and Blindness* 78:418- 25.

Muhammad, N., Maishanu, N. M., Jabo, A. M. and Rabiu, M. M. (2010) Tracing Children with Blindness and Visual Impairment Using the Key Informant Survey in a District of North-Western Nigeria’ Middle East African *Journal Ophthalmology*. 17(4): 330–334.

Murray, C.D. and Harrison, B. (2004) ‘The Meaning and Experience of being a Stroke Survivor: an interpretive phenomenological analysis *Disability and Rehabilitation* 26(13):808–816.

Nigerian Educational Research and Development Council (NERDC) (2008) *The New 9-year Basic Education Curriculum Structure* Abuja: NERDC Press.

Norman, K.,Caseau, D. and Stefanich, G. P. (1998) ‘Teaching Students with Disabilities in Inclusive Science Classrooms: Survey Results’ *Science Education* 82: 127-146.

Obiakor, F. E. (1992) ‘Education in Nigeria: A critical analysis’ *International Education 21*: 55-66.

Obiakor, F. E. (1998) Special Education in Nigeria: prospects and challenges. *European Journal of Special Needs Education 13*: 57-71.

Obiakor, F. E. (2006) ‘Special Education Reform in Nigeria: prospects and challenges’ *European Journal of Special Needs Education*. 13 (1): 57-71.

Obiakor, F. E. (2011) ‘Special Education Provision in Nigeria: analysing contexts, problems and prospects *International Journal of Special Education* 26 (1): 25-32.

Obiakor, F. E. and Maltby, G. P. (1989) *Pragmatism and Education in Africa: handbook for educators and development planners* Dubuque, IA: Kendall/Hunt.

Ogunmade, T.O. (2000) ‘Towards Professionalization of Science Teaching in the 21st century in Nigerian Schools: implications for teacher education. *Journal of Science and Movement Education* 3:1-6.

Okafor, C. F. and Anaduaka, U. S. (2013) ‘Nigerian School Children and Mathematics Phobia: how the Mathematics teacher can help *American Journal of Educational Research*. 1(7):247-251.

Oke, E. O. (2006) *Towards Providing Inclusive Education for School-Aged Children: the Ijanikin experience* http://www.icevi.org/publications/icevi_wc2006/09_inclusive_educational_practices/Papers/afr_042_enitan.pdf Accesses 20 June, 2013

Oluigbo, F. C. (1990) *National Curriculum for the Mentally Retarded* Lagos: Federal Ministry of Education.

OMCT– CLEEN Foundation (2005) *Report on the Implementation of the Convention on the Rights of the Child by Nigeria’, prepared for the Committee on the Rights of the Child, 38th Session,* Geneva, January 2005.

Omede A.A. (2009) ‘Challenges of Educating the Visually Impaired In Nigeria: Strategies for Improvement’ *Journal of the National Association for Science, Humanities and Education Research NASHERJ* 7(3): 114-119.

Omorogbe, E. and Ewansiha, J. C. (2013) The Challenge of Effective Science Teaching in Nigerian Secondary Schools. *Academic Journal of Interdisciplinary Studies.* 2(7) 181-188

Osakinle, E.O., Onijigin, E.O. and Falana, B.A (2010) Teaching Methods and Learners' Environment in a Nigerian University' *African Journal of Basic and Applied Sciences* 2 (1-2): 7-10.

Patton, M. (1990) *Qualitative Evaluation and Research Methods (2nd ed.)* Newbury Park, CA: Sage.

Patton, M. Q. (1999) 'Enhancing the Quality and Credibility of Qualitative Analysis' *Health Services Research* 34 (5 Part II):1189-1208.

Patton, M. Q. (2002) *Qualitative Research and Evaluation Methods,3rd edition* Thousand Oaks, CA: Sage.

Penrod, W. M., Haley, C. D. and Matherson, L. P. (2005) 'A model for Improving Science Teaching for Students with Visual Impairment' *Rehabilitation Education for Blindness and Visual Impairment* 37 (2):53-58.

Piggot-Irvine, E. (2006) "Sustaining Excellence in Experienced Principals? Critique of a Professional Learning Community Approach, *International Electronic Journal for Leadership in Learning*, 10(16). Retrieved July 24, 2012, from http://www.ucalgary.ca/iejll/vol10/irvine

Prasad R. (2001) *Model Figures* The Guardian 12th December 2001: 10-11.

PUBLIC LAW 108–446—DEC. 3, 2004 118 STAT. 2647. http://idea.ed.gov/download/statute.html

PUBLIC LAW 94-142—NOV. 29, 1975 89 STAT. 773 https://www.gpo.gov/fdsys/pkg/STATUTE-89/pdf/STATUTE-89-Pg773.pdf

Pugh, G. S. and Erin, J. (1999) *Blind and Visually Impaired Students: educational service guidelines* Watertown, MA: Perkins School for the Blind

Punch, K. (2005) *Introduction to Social Research: Quantitative and Qualitative Approaches*. London: Sage.

Quality Assurance Agency (QAA) (2007) *Subject benchmark statement: Mathematics, statistics and operational research* http://www.qaa.ac.uk/Publications/InformationAndGuidance/Pages/Subject-benchmark-statement-Mathematics-Statistics-and-operational-research.aspx accessed July 1st 2014.

Radway, J. (1984) *Reading the Romance* Chapel Hill: University of North Carolina Press.

Ramloll, R., Yu, W., Brewster, S., Riedel, B., Burton, M. and Dimigen, G. (2000) *Constructing Sonified Haptic Line Graphs for the Blind Students: first steps.* Paper presented at 4th International ACM Conference on Assistive Technologies, 13th-15th November 2000, pp. 17-25, Arlington, Virginia, USA.

Resnikoff, S., Pascolini, D. and Etya'ale, D. (2004) 'Global Data on Visual Impairment in the Year 2002. *Bulletin of the World Health Organisation* 82: 844-851.

Richards L. (1999) *Using Nvivo in Qualitative Research*. London: Sage;

Richards, K. (2003) *Qualitative Inquiry into TESOL* Basingstoke: Palgrave MacMillan.

Ricker, K. S. and Rodgers, N. C. (1981) 'Modifying Instructional Materials for use with Visually Impaired Students *The American Biology Teacher* 43(9):490-501.

Robson, C. (2002) 'The Analysis of Qualitative Data' in: *Real World Research: A Resource for Social Scientists and Practitioner-researchers* London: Blackwell :391-454.

Rowe, S. C. (2014) 'Counting on Technology: Critical Solutions for Education in STEM Subjects in Developing Countries' *The Educator* 27 (2):17-21.

Rowlett, E. J. (2008) 'Accessibility in MSOR: one student's personal experience' MSOR Connections 8 (1): 27-30.

Rowlett, E. J., and Rowlett, P. J. (2009) 'Visual Impairment in MSOR' *MSOR Connections* 9 (4): 43-46.

Rubin HJ, Rubin IS (1995) *Qualitative Interviewing. The Art of Hearing Data*. Sage

Publications, Thousand Oaks, CA.

Rudolph,J. L. (2005) Inquiry**,** Instrumentalism, and the Public Understanding of Science. *Science Education* 89(5):803-821.

Rutherford, F.J. and Ahlgren, A. (1990) *Science for All Americans* New York: Oxford University Press.

Sabina, Y. and Rahman K. F. (2012) ''Triangulation' Research Method as the Tool of Social Science Research' [PDF] - Bangladesh University of Professionals (*BUP) Journal*1 (1):154-163.

Sacks, S. Z. (2014) Social Interaction in C. B. Allman and S. Lewis (Eds) *ECC Essentials Teaching the Expanded Core Curriculum to Students with Visual Impairments*. New York:AFB Press:324-369

Sacks, S. Z., (1996) Psychological and social implications of low vision. In A. L. Corn & A. J. Koenig (Eds.), *Foundations of low visio*n. New York: AFB Press.

Sacks, S. and Wolffe, K. E. (2006) *Teaching Social Skills to Students with Visual Impairments: from theory to practice* New York: American Foundation for the Blind.

Sacks, S. Z., Wolffe, K. E. and Tierney, D. (1998) 'Lifestyles of Students with Visual Impairments: preliminary studies of social networks' *Exceptional Children*, 64:463-478.

Sahin, M. and Yorek, N. (2009) 'Teaching Science to Visually Impaired Students: a small-scale qualitative study' *US-China Education Review* 6 (4):19-26.

Salami, I. A. and Nweke, G. C. (2012) *Alternative Primary and Secondary Education and its Influence on Access to University Education and Self-efficacy of undergraduate students in Nigeria* Paper presented at the Open Society foundation and privatisation in Education Research Initiative African Regional Conference 12th-13th October in Johannesburg South Africa.

Salau, M. O. (1996) 'The Effect of Class Size on the Achievement of Different Ability Groups in Mathematics *Journal of the Science Teachers Association of Nigeria* 31(1&2): 55-61.

Salt, A., Lunney, D. and Hartness, R. (1980) 'General Purpose Talking Laboratory Instrument for the Visually Handicapped' *Review of Scientific Instruments*, 51:1710-1713.

Sapp, W. and Hatlen, P. (2010) 'The Expanded Curriculu: where we have been, where we are going, and how we can get there *Journal of Visual Impairment and Blindness* 104(6):338-348.

Sawhney, K. (2014) *STEM Access for the Blind and Visually Impaired Perspectives in Assistive Technology* http://stanford.edu/~kartiks2/stem-access.pdf. Accessed 10th March, 2015

Scadden, L. (2005) *Current Status of People with Disabilities in STEM Education: A Personal Perspective*; Las Cruces, NM: Regional Alliance for Science, Engineering, & Mathematics - Squared (RASEM2).

Schindele, R. A. (1985) 'Research Methodology in Special Education: a framework approach to special problems and solutions' In S. Hegarty. and P. Evans(Eds) *Research and Evaluation Methods in Special Education.* Windsor: NFER-NELSON Publishing Company:2-24

Schmidt, W. H., McKnight, C. C., Houang, R. T., Wang, H. A., Wiley, D. E., Cogan, L. S., et al. (2001). *Why schools matter: A cross-national comparison of curriculum and learning*. San Francisco: Jossey-Bass.

Schneider, S. J., Kerwin, J., Frechtling, J. and Vivari, B. A. (2002) ‘Characteristics of the Discussion in Online and Face-to-Face Focus Groups’ *Computer Review* 20:31.

Schweisfurth, M. (2011). Learner-centred education in developing country contexts: from solution to problem? *International Journal of Educational Development*, 31, 425–432.

Schweisfurth, M. (2013). *Learner-centred education in international perspective: whose pedagogy for whose development*? London: Routledge.

Seale, C. and Silverman, D. (1997) ‘Ensuring Rigour in Qualitative Research’ *The European Journal of Public Health 7*(4): 379-384.Shakespeare, T. (2006). The social model of disability. *The disability studies reader*, *2*, 197-204.

Shakespeare, T. (2006). *Disability rights and wrongs*. New York: Routledge.

Sheehy, K. (2013) ‘Educational Psychology and the Development of Inclusive Education’ in A. Holliman (Ed) *Educational Psychology*: *an international perspective*. London: Routledge.

Shenton, A. K. (2004) ‘Strategies for Ensuring Trustworthiness in Qualitative Research Projects’ *Education for information 22*(2): 63-75.

Sheppard, L., and Aldrich, F. K. (2001) ‘Tactile Graphics in School Education: perspectives from teachers *British Journal of Visual Impairment* 19 (3): 93-97.

Silverman, D. (1998) ‘Qualitative Research: meanings or practices? *Information Systems Journal*, 8(1): 3-20.

Silverman, D. (2013) *Doing qualitative research: a practical handbook* London: Sage.

Smith, M. K. (2007) *Action research: The Encyclopedia of Informal Education.* http://infed.org/mobi/action-research/. accessed25th May, 2015.

Stone, E. M. (2014) ‘Guiding Students to Develop an Understanding of Scientific Inquiry: A Science Skills Approach to Instruction and Assessment’ *Life Sciences Education* 13(1):90–101.

Strauss, A., and Corbin, J. (1998) *Basics of Qualitative Research: procedures and techniques for developing grounded theory* Thousand Oaks, CA: Sage.

Stringer, E. T. (2007) *Action Research (3rd Edition)* London: Sage.

Supalo, C. (2005) ‘Techniques to Enhance Instructors’ Teaching Effectiveness with Chemistry Students who are Blind or Visually Impaired’ *Journal of Chemical Education* 82(10): 1513-1518.

Supalo, C. (2007) ‘Independent Laboratory Access for the Blind’ *Braille Monitor* 50 (5).

Supalo, C.A. (2010) ‘Teaching chemistry and other sciences to blind and low-vision students through hands-on learning experiences in high school science laboratories’ *Doctoral dissertation* The Pennsylvania State University Available from ProQuest Dissertations and Theses database. (UMI 3442959). Accessed 4th March, 2011

Supalo, C. A. (2012) ‘The Next Generation Laboratory Interface for Students with Blindness or Low Vision in the Science Laboratory’ *Journal of Science Education for Students with Disabilities*: . 16(1)

Supalo, C. A. (2013) ‘A Historical Perspective on the Revolution of Science Education for Students Who Are Blind or Visually Impaired In the United States’ *Journal of Science Education for Students with Disabilities* 17(1) 53-56

Supalo, C. A. and Kennedy, S. H. (2014) ‘Using commercially available techniques to make organic chemistry representations tactile and more accessible to students with blindness or low vision’ *Journal of Chemical Education* 91(10): 1745-1747.

Supalo, C., Kreuter, R. A., Musser, A., Han, J., Briody, E., McArtor, C., Gregory, K. and Mallouk, T. E. (2006) ‘Seeing Chemistry Through Sound: a submersible audible light sensor for observing reactions in real time’ *Assistive Technology Outcomes and Benefits* 3 (1): 110-116.

Supalo, C. A., Mallouk, T. E., Amorosi, C., Lanouette, J. Wohlers H. D. and McEnnis, K. (2009) ‘Using Adaptive Tools and Techniques to Teach a Class of

Supalo, C., Mallouk, T**.,** Amorosi, C., Rankel,L., Wohlers, D., Roth, A., and Greenberg, A. (2007) ‘Talking Tools to Assist Students Who Are Blind in Laboratory Courses’ *Journal of Science Education for Students with Disabilities* 12 (1): 27-32.

Supalo,C. A., Mallouk, T. E; Amorosi, C.; Graybill, C. M. (2008). Low Cost Laboratory Adaptations for Precollege students who are blind or visually impaired. *Journal of Chemical Education***.** 85 (2)243-247

Taylor, P. (1993) ‘Collaborating to Reconstruct Teaching: the influence of researcher beliefs’ in K. Tobin (Ed.) *The Practice of Constructivism in Science Education* Hillsdale, NJ: Lawrence Erlbaum: 267-297.

Taylor, P.C. and Medina, M.N.D. (2013) ‘Educational Research Paradigms: from positivism to multiparadigmatic’ *Journal for Meaning Centered Education,1* http://www.meaningcentered.org/journal/volume-01/educational-research-paradigms-from-positivism-tomultiparadigmatic/ Accessed 5th June, 2015. [Open access journal; no page numbers]

Tesch, R. (1990) *Qualitative Research Analysis Types and Software Tools* New York: Falmer Press.

Thomas, G. (2009) *How to do your Research Project* London: Sage.

Thomas, G. (2010a) *How To Do Your Case Study: A Guide for Students and Researchers* London: Sage.

Torgerson, D. J. and Torgerson, C. J. (2003) 'Avoiding Bias in Randomised Controlled Trials in Educational Research' *British Journal of Educational Studies* 52 (1): 36-45

Turnbull, H. R. Huerta, N. and Stowe, M. (2004) *The Individuals with Disabilities Education Act as Amended* Upper Saddle River, NJ: Pearson Education: pp 1-10

Udoh, O. A. (2008) 'An Analysis of Classroom Interaction of Senior Secondary School Chemistry Teachers in Ikot Ekpene Local Government Area of Akwa Ibom State Nigeria' *Journal of the Science Teachers Association of Nigeria* 43 (1 & 2): 16-22.

UNESCO and Ministry of Education and Science, Spain (1994) *The Salamanca Statement and Framework for Action on Special Needs Education, Adopted at the World Conference on Special Needs Education: Access and Quality,* Salamanca, Spain*,* June 7-10

UNICEF/Federal Government of Nigeria (2001) *Children's and Women's Rights in Nigeria: A Wake-up Call A Situation Assessment and Analysis, 2001* Abuja: FGN

Universal Basic Education Commission (2004) *Standard Action Plan based on UBE Act*. Nigeria. Lagos: FGN

Uwaifo, V. O. and Uddin, P.S.O. (2009) 'Transition from the 6-3-3-4 to the 9-3-4 System of Education in Nigeria: an assessment of its implementation on Technology Subjects' *Studies in Home and Communnity Sciences* 3(2): 81-86.

Vygotsky, L. (1978). Mind in Society: The Development of Higher Psychological Processes. Cambridge: Harvard University Press.

Waterman, H; Tillen, D; Dickson, R; de Koning, K (2001) Action Research: A Systematic Review and Guidance for Assessment. Health Technology Assessment; 5(23).

Watkins, D and Akande, A. (1994) 'Approaches to learning of Nigerian Secondary School Children: emic and etic perspectives' *International Journal of Psychology* 29(2):165-182

Webb, E. J., Campbell, D. T., Schwartz, R. D. and Sechrest, L. (1966) *Unobtrusive Measures: Nonreactive Measures in the Social Sciences* Chicago: Rand McNally.

West African Examinations Council (2005-2007) *Mark Sheet for Blind Candidates. May/June WASSC Examination* Lagos: YABA.

Wild, T, Hilson, M. and Farrand, K. (2013) ‘Students with Visual Impairment Conceptual Understanding of Geological Concepts *Journal of Geoscience Education* 61: 222-230.

Wild, T., Hilson, M. and Hobson, S. (2013) ‘Conceptual Understanding of Sound by Elementary Students with Visual Impairments’ *Journal of Visual Impairment and Blindness* 107 (2):107-116.

Wild, T. and Paul, P. (2012) ‘Perceptions of Science Educational Practices for Students with Visual Impairments *Insight: Research and Practice in Visual Impairment and Blindness* 5(2): 93-99.

Wild, T. and Trundle, K. (2010) ‘Conceptual Understanding of Middle School Students with Visual Impairment Concerning Seasonal Change’ *Journal of Visual Impairment and Blindness* 104 (2):107-118.

Williams, R.M. and Irving, A.J. (2012) ‘On the Accessibility of Mathematics to Visually Impaired Students in Higher Education in E.Cliffe and P. Rowlett (Eds.) *Good practice on Inclusive Curricula in the Mathematical Sciences* York: The Higher Education Academy:19 - 23.

Wilson, Z., Holmes, I., deGravelles, K., Sylvain, M. Batiste, L. and Johnson, M. et al (2012) Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate STEM disciplines. *Journal of Science Education and Technology.* 2(1) 148-156

Winter R. (1996) ‘Some Principles and Procedures in the Conduct of Action Research’ in Zuber-Skerritt O. (ed.) *New Directions in Action Research* London: Falmer Press.

Wohlers, H. D. (1994) ‘Science Education for Students with Disabilities’ in J. Egelston-Dodd (ed.), *A Future Agenda: proceedings of a working conference on science for persons with disabilities*. Iowa: University of Northern Iowa,:52-64.

Wolery, M. and Harris, S. R. (1982) Interpreting results of single-subject research designs. Physical Therapy, 62, 445-452

Wolffe, K. (1999) *Skills for Success: A Career Education Handbook for Children and Adolescents with Visual Impairments* New York: American Foundation for the Blind.

Wolffe, K. E. and Kelly, S. M. (2011) ‘Instruction in Areas of the Expanded Core Curriculum Linked to Transition Outcomes for Students with Visual Impairments’ *Journal of Visual Impairment and Blindness* 105(6): 340-349.

Wolffe, K. E. and Rosenblum, L. P. (2014) ‘Self-Determination’ in C.B. Allman and S. Lewis, S (Eds) *ECC Essentials: Teaching the Expanded Core Curriculum to Students with Visual Impairments* New York: AFB Press :470-510).

Wolffe, K., Sacks, S., Corn, A., Erin, J., Huebner, K. and Lewis, S. (2002) ‘Teachers of Students with Visual Impairments: What are they teaching? *Journal of Visual Impairment and Blindness* 96: 293-304.

Wolffe, K.E., & Sacks, S. Z. (1997) The social network pilot project: Lifestyles of students with visual impairments. *Journal of Visual Impairment & Blindness*, *91*, 245-257

World Health Organization (1980) *International Classification of Functioning Disability and Health* Geneva: WHO.

World Health Organization (2001) *International Classification of Functioning Disability and Health* Geneva: WHO.

World Health Organization (2012). Global data on visual impairment 2012

Wright, P. D. W. (2005) *IDEA 2004* Hartfield, Va: Harbor House Law Press: 9-10.

www.ncaer.net/.../ExpandedCoreCurriculumOverviewrevised9-11-12.do. Accessed 4th February,2013

Yin, R. K. (1984) *Case study research: Design and methods.* Newbury Park, CA: Sage.

Yin, R. K. (2003) *Case study research: Design and methods (3rd edition)* Thousand Oaks, CA: Sage.

APPENDICES

RELATED TO THE EXPLORATORY STUDY

Appendix Ia:

EXPLORATORY STUDY PHONE INTERVIEW SCHEDULE FOR THE TEACHERS

The teachers were asked the following questions. Before commencing the interview additional explanation was given to confirm their understanding of the content of the information sheet and informed consent earlier sent to the teachers through their principals; they were re-assured that the interview is only for research purpose. The respondents were also informed that the interview will be recorded and that it will last for ten minutes. If the respondent disagrees he/she should hang up the telephone or wait for the interview questions if he/she agrees.

1. Can you tell me the name of your School? May I know your age?
2. What are your qualifications?
3. Which subject do you teach?
4. How long have you been teaching the subject?
5. Do you have any Visually Impaired students in your school or class? How many are they?
6. What is the average age of the students?
7. Are they residential?
8. Do they all use Braille?
9. Do visually impaired students in your School have same level of vision?
10. Do they participate in all lessons?
11. Can you please tell me your role?
12. Is there any difference in teaching Science to the visually impaired and the sighted?
13. Please highlight the differences
14. Do you have special equipment for teaching science to the visually impaired?
15. What are the barriers you experience in teaching science to the VI?
16. Do children with VI participate in science class?
17. What role do they play during science activities?
18. How are they assessed during tests and examinations in science?
19. Can you comment on the interest of the Visually Impaired in science?
20. What Barriers do they face in learning science?

Appendix Ib

TEACHERS INFORMATION SHEET FOR THE EXPLORATORY STUDY

UNIVERSITY OF BIRMINGHAM

Hello! My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK on identifying the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level in south-western Nigeria. The world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institution to be in favour of science courses. The more reason why accessibility of science curriculum to the visually impaired students' needs to be investigated with the aim of improving the situation in the future.

I would like you to take part in this study as a teacher of the visually impaired.

Please complete the attached brief questionnaire in less than ten minutes by ticking the most appropriate option for each question and filling the spaces in the second part as applicable. If you do not want to answer a question for any reason, please omit it and carry on.

You will not be identified in any way from the research results and you can withdraw at any stage and your data will be removed as promised in the consent letter. The information will be treated as confidential and will only be used for the purpose of the research. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me. Completed questionnaire should be returned with the enclosed prepaid envelope. An honorarium of N200.00 shall be given for returned questionnaire before July 2011. Your participation is important and is highly appreciated

To contact me

Or my supervisor

Dr Steve McCall

E. mail:

Appendix Ic

EXPLORATORY STUDY INFORMED CONSENT FOR THE TEACHERS

Hello!

Who am I? I am Sariat Adelakun, an MPhil/PhD student in the School of Education, University of Birmingham, UK. I am conducting a research on identifying the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level in south-western Nigeria. As a **science teacher of the visually impaired studen**t, I would like to invite you as one of the participants for this research study.

My research topic: Science is one of the compulsory subjects in the nine year basic education in Nigeria. Education of the visually impaired in Nigeria is not adequately developed despite the ‘Education for All’ slogans of the National policy on Education and there are great difficulties relating to the inclusion of children with Visual Impairment in the curriculum and to involvement in Science classes in particular. Science Education is a very important element of the curriculum and children should not be exempted form it on grounds of their visual impairment. The National policy on Education stresses that an illiterate of today could be identified by the knowledge and application of science by such individual. Science gives meaning to happenings within and around an individual. A visually impaired need to be able to explain, appreciate and contribute to happening around in this world that is dominated with products of science.

It is therefore very important to identify the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level with the aim of improving the accessibility.

How can you help me? Your participation will require granting me audience to interview you for 10 minutes, permit me to observe your science lessons. OR You will need to complete a questionnaire that is provided in normal print, Braille and large print depending on the one suitable for you after participating in a training.

Your rights: You do not have to collaborate in this research study. It is completely your own decision and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the study in the middle or up to the time of data analysis. In that case, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisor:

Email: [redacted]

Research supervisor

Dr Steve McCall

Email:

Thank you for giving your time

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed.

Name:-------------------------------------Signature:---------------------------------

Appendix Id

EXPLORATORY STUDY PHONE INTERVIEW SCHEDULE FOR THE STUDENTS WITH VISUAL IMPAIRMENTS (SVI)

The following questions were asked from the student. They were re-assured that the interview is only for research purpose. The respondent was also informed that the interview will be recorded and that it will last for ten minutes, they were asked to hang up the phone if they don't want to participate.

1. Can you tell me the name of your School? May I know your age?
2. What class are you?
3. Are you visually impaired? How many visually impaired students are in your school/class?
4. Are you residential?
5. Do you all have the same level of vision/ Are you all blind or some are partially sighted.
6. Do you all use Braille?
7. Do you participate in all lessons?
8. Is there any difference in the way science is taught to the visually impaired and the sighted?
9. Please highlight the differences if there is any
10. Do your teachers use special equipment for teaching science to the visually impaired?
11. What are the barriers you experience in learning science?
12. Do you participate in science activities? What role do you play during science activities?
13. How are you assessed during tests and examinations in science?
14. Are you interested in studying science?
15. What Barriers do you face in learning science?

Appendix Ie

STUDENTS INFORMATION SHEET FOR EXPLORATORY STUDY

Hello!

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK on identifying the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level in south-western Nigeria. The world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institution to be in favour of science courses. The more reason why accessibility of science curriculum to the visually impaired students needs to be investigated with the aim of improving the situation in the future.

I would like you to take part in this study as a visually impaired student.

Please complete the attached brief questionnaire by typing the appropriate answer/ticking the most appropriate option for each question/statement and filling the spaces in the second part as applicable. If you do not want to answer a question for any reason, please omit it and carry on.

You will not be identified in any way from the research reports and you can withdraw at any stage and your data will be removed as promised in the consent letter. The information will be treated as confidential and will only be used for the purpose of the research. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me. Completed questionnaire should be returned with the enclosed prepaid envelope. An honorarium of N100.00 shall be given for returned questionnaire before July 2011. Your participation is important and is highly appreciated

To contact me

[redacted]

Or my supervisor

Dr Steve McCall E. mail: [redacted]

Appendix If

EXPLORATORY STUDY INFORMED CONSENT FOR STUDENTS

UNIVERSITY OF BIRMINGHAM

Hello!

Who am I? I am Sariat Adelakun, an MPhil/PhD student in the School of Education, University of Birmingham, UK. I am conducting a research on identifying the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level in south-western Nigeria. As a **visually impaired student,** I would like to invite you as one of the participants for this research study.

My research topic: Science is one of the compulsory subjects in the basic education level in Nigeria. Education of the visually impaired in Nigeria is not adequately developed despite the 'Education for All' slogans of the National policy on Education and there are great difficulties relating to the inclusion of children with Visual Impairment in the curriculum and to involvement in Science classes in particular. Science Education is a very important element of the curriculum and children should not be exempted form it on grounds of their visual impairment. The National policy on Education stresses that an illiterate of today could be identified by the knowledge and application of science by such individual. It is therefore very important to identify the resources and teaching strategies that will give visually impaired children access to the science curriculum at junior secondary school level with the aim of improving the accessibility.

How can you help me? Your participation will require granting me audience to interview you for 5-7 minutes. OR You will need to complete a questionnaire that is provided in Braille and large print depending on the one suitable for you.

Your rights: You do not have to collaborate in this research study. It is completely your own decision and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the study in the middle or up to the time of data analysis. In that case, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisor:

Email:

Research supervisor

Dr SteveMcCall

Email:

Thank you for giving your time

Thank you for giving your time

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed.

Name:------------------------------------ Signature:------------------------------

Appendix Ig

TEACHERS QUESTIONNAIRE FOR THE EXPLORATORY STUDY

PART I

Please tick as appropriate

1. How old are you? ☐ 20-30 ☐ 31-40 ☐ 40-60

2. What is the name of your School……………………………………………..

3. Which class do you teach? ☐ JSS 1 ☐ J ☐ SS 2 JSS3

4. Which subject do you teach? ☐ Basic Science ☐ others

5. Are there visually impaired in your Class? ☐ YES ☐ NO

6. How many? ☐ 1 - 5 ☐ more than 5

7. How long have you been teaching Basic Science? ☐ 0-5years ☐ more than 5years

8. Qualifications ☐ NCE ☐ B Sc ☐ others

9. Specialisation ☐ Science/SVI ☐ Science ☐ others

PART II

S/N		SD	D	U	A	SA
10	The visually impaired are exempted from science subjects;					
11	visually impaired students are involved in science activities,					
12	There are adapted equipment or special equipment for teaching science in my school;					
13	Visually impaired students have barriers in learning science;					
14	Visually impaired students learn science with brailed labeled models.					

Part III

1. What do you think are likely barriers preventing visually impaired to access science?
   ……………………………………………………………………………………
   ……………………………………………………………………………………
2. Suggest possible steps to remove the barriers.
   ……………………………………………………………………………………
   ……………………………………………………………………………………
3. Suggest resources that could be provided to adequately teach the visually impaired science.
   ……………………………………………………………………………………
   ……………………………………………………………………………………
4. Do the visually impaired show any interest in science? ☐ YES ☐ NO

Tick the right box

5a. If YES how do they show interest? ……………………………………………………………………………………..…

……………………………………………………………………………………………………

5b. If NO suggest how their interest in science could be developed?...................................

…………………………………………………………………………………………………

…………………………………………………………………………………………………

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.

PLEASE NOW RETURN IT TO US USING THE REPLY-PAID ENVELOPE PROVIDED. (Provide a bank account number for your promise)

Appendix Ih

EXPLORATORY STUDENT QUESTIONNAIRE [BRAILLE AND MAGNIFIED COPIES WAS PROVIDED]

Part I

What is the name of your school? ....

1. What type of school is your school ☐ *special school* ☐ *mainstream school* (*tick the appropriate box)*

2. Which Junior Secondary class are you in ☐ 1 ☐ 2 ☐ 3

3. How many of you are visually impaired in your class? ____________________

Part II

Rate the following statement and tick the box that best represent your agreement with each statement:

SD Strongly disagree

D Disagree

U Unsure

A Agree

SA Strongly agree

S/N		SD	D	U	A	SA
1	I take active part during basic science lesson					
2	Our science teacher uses adapted equipment to teach us science					
3	I don't like science, because I cannot follow what the teacher teaches. No equipment					
4	I never attend basic science lesson					
5	I like to do science because our teachers use Braille labelled models to teach us science lessons					
6	I read other things during science class					
7	Our resource teacher teaches us science activities after science lesson					
8	We don't have extra teaching on science					
9	I am always happy when we have basic science					
10	Visually impaired student don't do science					

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE. PLEASE NOW RETURN IT TO US USING THE REPLY-PAID ENVELOPE PROVIDED. (Provide a bank account number for your promise)

Appendix Ii

Exploratory teacher questionnaires responses coded

Teachers questionnaires														
Participants	Results_Q_1	Results_Q_2	Results_Q_3	Results_Q_4	Results_Q_5	Results_Q_6	Results_Q_7	Results_Q_8	Results_Q_9	Results_Q_10	Results_Q_11	Results_Q_12	Results_Q_13	Results_Q_14
1	2	1	1	1	1	1	2	2	2	5	1	1	5	2
2	1	2	1	1	1	1	2	1	2	5	1	1	5	5
3	1	2	1	1	1	1	2	1	2	5	1	1	5	5
4	2	3	2	1	1	2	1	1	2	5	1	1	5	5
5	3	3	2	1	2	2	2	2	2	5	1	1	5	2
6	1	3	3	1	1	2	2	1	2	2	1	3	5	5
7	2	1	1	1	1	1	2	1	2	5	1	1	5	5
8	3	1	2	1	1	1	1	1	2	5	1	1	5	5
9	3	1	3	1	1	1	2	2	2	5	1	2	5	5
10	3	1	3	1	1	1	1	1	1	5	1	2	5	4
11	2	5	3	1	1	2	1	2	2	5	2	4	5	2
12	2	4	1	1	1	1	2	1	2	2	1	1	5	3
13	1	4	2	1	2	1	1	1	2	5	4	4	5	4
14	3	5	2	1	1	2	2	1	2	3	2	2	5	5
15	1	4	1	1	1	1	1	3	2	5	1	2	5	5

RELATED TO SEARCH CONFERENCES

Appendix IIa:

INFORMATION SHEET FME AND STATE COMMISSIONER FOR EDUCATION

Dear Sir,

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit on participation and independence of students with visual impairment in Basic Science in South-Western Nigeria.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Therefore, it is necessary to evaluate resources and teaching technique that could improve SVI's access to science and Mathematics.

Please permit me to invite a representative of your ministry to a search conference to share ideas on problems of access to science by the SVI and also with other stakeholders proffer solutions to the problem. The search conference is also an initiation of collaboration with all stakeholders. [Consultation]

I also want to request permission to conduct my research in secondary schools under your authority, I also request you to sponsor the Science and Mathematics teachers in schools mainstreaming SVI to the search conference and a day training session on the resources that could be used to involve SVI in science. Your schools and teachers will not be identified in any way from the research reports, you can withdraw within one month to date of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored with a strong password in zipped folder that will only be available to me and my supervisor. Your participation is important and will be highly appreciated.

If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

To contact me

Sariat Adelakun

[redacted]

Or my supervisor:

Dr Graeme Douglas
Email: [redacted]

Appendix IIb:

Consent form for FME and State commissioner for education

Dear Sir,

Who am I?I am Sariat Adelakun, a PhD student in the School of Education, University of Birmingham, UK. I am evaluating the impact of Talking LabQuest and special STEM Kit on participation, and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. As the Director of special education at the Federal Ministry of EducationI would like to invite your schools and Basic Science teachers as participants for this research study.

My research topic: All round education is a right of every citizen. As you know science is one of the compulsory subjects in the basic education level in Nigeria. There are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in science classes in particular. It is therefore very important to evaluate impact of Talking LabQuest and special STEM Kit that could improve SVI's access to science and Mathematics.

How can you help me? Permit me to invite a representative of your ministry to a search conference on problem of access to science by SVI.I also wish to seek your consent to allow me to use the schools under your authority for my research. I also want you to sponsor Basic Science teachers in schools mainstreaming SVI to one-day training on the use of Talking LabQuest and special STEM Kit. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions and you will not be identified in the recordings.

Your rights:You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse my request without giving me any reason. You may also withdraw your schools from the study within one month to the time of data collection. In case of withdrawal, the given data and information will be removed and the data will be destroyedimmediatelyI must assure you that the information collected will be kept confidential. Names of schools and participants will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisors:

Email:

Research supervisor:

Dr Graeme Douglas

Email:

NOTE: PLEASE KEEP THE CONSENT FORM, SIGN THE ATTACHED SLIP ANDRETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU.

Sariat

Appendix IIc

SUBEB INFORMATION SHEET

Dear Sir,

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit on participation and independence of students with visual impairment in Basic Science/Mathematics in South-Western Nigeria.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement for admission to all tertiary institutions.

Therefore, it is necessary to evaluate resources that could improve SVI's access to all aspects of science and mathematics. Please permit me to invite a representative of your establishment to a search conference to share ideas on problems of access to science by the SVI and jointly collaborate in the research to find solution to the problem. This will be done with representative of the Honourable commissioner of education, teachers and SVI in your secondary schools. I also want to request permission to involve Science and Mathematics teachers in secondary schools under your authority, I request that you sponsor the relevant teachers and SVI to the search conference. I also request you to allow the Science/Mathematics teachers in schools mainstreaming SVI to partake in a a day training session on the resources that can improve SVI participation in Science and Mathematics. Your schools and teachers will not be identified in any way from the research reports, you can withdraw through email/call within one month to the date of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. Your participation is important and will be highly appreciated.

If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

To contact me

[redacted]

Or my supervisor:
Dr Graeme Douglas
Email: [redacted]

Appendix IId

Consent form for SUBEB

Dear Sir

Who am I? I am Sariat Adelakun, a PhD student in the School of Education, University of Birmingham, UK. I am evaluating the impact of Talking LabQuest and special STEM Kit on participation, and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. As the SUBEB Director of Special EducationI would like to invite your schools and teachers as participants for this research study.

My research topic: My research topic: All round education is a right of every citizen. As you know science is one of the compulsory subjects in the basic education level in Nigeria. There are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in science classes in particular. It is therefore very important to evaluate impact of Talking LabQuest and special STEM Kit that could improve SVI's access to science and Mathematics

How can you help me? Permit me to invite a representative of your ministry to a search conference on problem of access to science by SVI.I also wish to seek your consent to allow me to use the schools under your authority for my research. I also want you to sponsor Basic Science/Mathematics teachers in schools mainstreaming SVI to a day training on the use of Talking LabQuest and special STEM Kit. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions and you will not be identified in the recordings.

Your rights: You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse my request without giving me any reason. You may also withdraw your schools from the study within one month to time of data collection. In case of withdrawal, the given data and information will be removed and the data will be destroyed immediatelyI must assure you that the information collected will be kept confidential. Names of schools and participants will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisors:

Email:
Research supervisors:
Dr Graeme Douglas
Email:
NOTE

PLEASE KEEP THE CONSENT FORM, SIGN THE ATTACHED SLIP AND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU.
Sariat

Appendix IIe

TEACHERS INFORMATION SHEET FOR THE SEARCH CONFERENCE

Hello! My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science in South-Western Nigeria. Specifically, you will need to participate in today's search conference (10am to 4pm) with other stakeholders to determine the status of the problems of access to science by the SVI and seek your collaboration in the study.

At this conference I want to find out the current situation from participant's experiences. I will share with us some global issues on the topic and I would seek your collaborations in the research study.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. and made admission to tertiary institutions to be in favour of science courses**.** Therefore, it is necessary to find ways of involving SVI actively in science subjects. I would like you to take part in this study as a Science/Mathematics teacher in a school mainstreaming students with visual impairment.

I will like to use Camera to video record and your faces will be blurred in the recording to ensure confidentiality but the recording will allow adequate documentation of data. It will be recorded in a way that will not disclose your identity You will not be identified in any way from the research reports, you can withdraw at any point today, call or send email to me in case you want to withdraw within one month to the time of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored in a zipped folder protected with a strong password. The folder will only be available to me and my supervisor. The data will be retained according to University ethics for a period of ten years.

Your participation is important and will be highly appreciated. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

To contact me

Sariat Adelakun

[redacted]

Or my supervisor:

Dr Graeme Douglas

Email: [redacted]

Appendix IIf

Teachers informed consent for the search conference

Hello!

Who am I?I am Sariat Adelakun, a PhD student in the School of Education, University of Birmingham, UK. I am investigating how to improve access of students with visual impairment (SVI) to Basic Science and in South-Western Nigeria. Specifically, as a science teacher in a mainstream classroomwith students with visual impairment, I would like to invite you as one of the participants for this research study.

My research topic: Science is one of the compulsory subjects in the nine-year basic education in Nigeria and there are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in Science classes in particular. Knowledge of science enables individuals to eliminate misconceptions surrounding happenings in the universe and a visually impaired also need to be able to explain, appreciate and contribute to happening around in this world that is dominated with products of science. It is therefore very important to collaborate to bring about a change

How can you help me? Your involvement will require participation in a search conference today (10am-4pm). I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions and you will not be identified in the recordings.

Your rights: You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the conference anytime or by calling me or through email after the conference within one month to the time of data collection. In case of withdrawal , the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisor:

Email:
Research supervisors:
Dr Graeme Douglas
Email:
NOTE

PLEASE KEEP THE CONSENT FORM, SIGN THE ATTACHED SLIP AND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU

Sariat

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed if the withdrawal is within one month to the time of data collection.

Appendix IIg

SVI INFORMATION SHEET FOR THE SEARCH CONFERENCE

Hello! My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science/Mathematics in South-Western Nigeria. Specifically, you will need to participate in today's search conference (10am to 4pm) with other stakeholders to determine the status of the problems of access to science by the SVI and seek your collaboration in the study.

At this conference I want to find out the current situation from participant's experiences. I will share with us some global issues on the topic and I would seek your collaborations in the research study.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement for admission to all tertiary Institution in Nigeria. Therefore, it is necessary to evaluate resources that could improve SVI's access to science.

I will like to use Camera to video record and your faces will be blurred in the recording to ensure confidentiality but the recording will allow adequate documentation of data. It will be recorded in a way that will not disclose your identity You will not be identified in any way from the research reports, you can withdraw at any point today, call or send email to me in case you want to withdraw within one month to the time of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored in a zipped folder protected with a strong password. The folder will only be available to me and my supervisor. The data will be retained according to University ethics for a period of ten years.

Your participation is important and will be highly appreciated. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

To contact me

Sariat Adelakun

[redacted]

Or my supervisor:
Dr Graeme Douglas
Email: [redacted]

Appendix IIh

Students informed Consent [SVI]

(Was presented in Braille and enlarged font for blind and low vision participants respectively added to the normal print copy for their parents)

Hello!

Who am I?I am Sariat Adelakun, a/PhD student in the School of Education, University of Birmingham, UK. I am evaluating the impact of Talking LabQuest and special STEM Kit on participation, and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. As a student with visual impairment,I would like to invite you as one of the participants for this research study.

My research topic: All round education is a right of every citizen. As you know science is one of the compulsory subjects in the basic education level in Nigeria. There are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in science classes in particular. It is therefore very important to evaluate impact of Talking LabQuest and special STEM Kit that could improve SVI's access to science and Mathematics

How can you help me? Your participation will require participation in focus group interviews to be able to assess the resources. I also need to observe your basic science and Mathematics lessons. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions you and will not be identified in the recordings.

Your rights: You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the conference anytime today or within one month to the date of data collection. In case of withdrawal, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details:For any information and queries regarding my research project and the findings, you are free to contact me or my supervisors:

Email: [redacted]
Research supervisor:
Dr Graeme Douglas
Email: [redacted]

NOTE: PLEASE KEEP THE CONSENT FORM AND SIGN THE ATTACHED SLIPAND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TOPARTICIPATE. THANK YOU

Sariat

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed if the withdrawal is within one month to the time of data collection.

Name:------------------------------------Signature:--------------------------------

FOR THE STUDY SCHOOLS

Appendix IIIa

TEACHERS INFORMATION SHEET FOR THE STUDY SCHOOLS

Hello!

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science and Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of the Independence Science and special STEM kit on participation and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. How has science enhanced their independence?

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement in all tertiary institutions in Nigeria for all courses. Therefore, it is necessary to find ways of involving SVI actively in the two subjects. I would like you to take part in this study as a Science/Mathematics teacher in a school mainstreaming students with visual impairment.

Please permit me to conduct e-mails interviews with you on the teaching of Science/Mathematics to the SVI and your perceptions of the resources been introduced during the process of my research. The interview will take between 10-15minutes of your time. You will respond to the questions at your own convenience since it is through email. You can use email opened with pseudonyms to ensure confidentiality.

I also want to observe three of your Science/Mathematics lessons in a mainstream classroom to study how SVI participates in the science and mathematics lessons taught with Talking LabQuest and special STEM kit. The lessons will be video recorded with a camera in a way that will not show the participants (faces will be blurred). During the lessons you can use pseudonyms for confidentiality of the participants. The participation and engagement of the SVI with the resources will be observed during the lessons.

You will also attend a training session on the effective use of the resources. You will not be identified in any way from the research reports, you can withdraw within one month to the time of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data collected will be kept and protected with a strong password in a Zip folder on a computer that will be available only to me and my supervisor. Your participation is important and will be highly appreciated.

If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

Sariat Adelakun

[redacted]

Or my supervisor:
Dr Graeme Douglas
Email: [redacted].

Appendix IIIb

SVI INFORMATION SHEET FOR THE STUDY SCHOOLS

Hello!

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Basic Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit on participation and independence of students with visual impairment in Basic Science in South-Western Nigeria.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement for admission to all tertiary Institution in Nigeria. Therefore, it is necessary to evaluate resources that could improve SVI's access to science and mathematics.

Please permit me to invite you to participate in the research as SVI. You will need to participate in two days training (during school hours in your school) to use resources designed for enabling SVI to take active part in Science and Mathematics activities. Your knowledge of additional curriculum necessary for SVI will also be assessed. Three Science and Mathematics lessons will also be observed to see how you use the resources independently/confidently during the lessons. You will also take part in 60minutes focus group interviews (all the SVI in your class level) in your preferred place within your school compound after using the resources. This will enable me to find out your assessment of usefulness of the resources and suggestion that will bring a better usefulness. You can use pseudonyms during the focus group discussions to ensure confidentiality. I will like to use Camera to video record the interview and classroom activities to capture your engagement with the resources. Your faces will be blurred in the recording to ensure confidentiality but the recording will allow adequate documentation of data.

It will be recorded in a way that will not disclose your identity You will not be identified in any way from the research reports, you can call or send email to me in case you want to withdraw within one month to the time of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored in a zipped folder protected with a strong password. The folder will only be available to me and my supervisor. The data will be retained according to University ethics for a period of ten years.

Your participation is important and will be highly appreciated. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

Sariat Adelakun

Or my supervisor:
Dr Graeme Douglas
Email:

Appendix IIIc

PARENTS INFORMATION SHEET [FOR STUDENTS UNDER 18 YEARS] IN STUDY SCHOOLS

Hello!

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit on participation and independence of students with visual impairment in Basic Science in South-Western Nigeria.

You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement for admission to all tertiary Institution in Nigeria. Therefore, it is necessary to evaluate resources that could improve SVI's access to science and mathematics.

Please permit me to invite your Son/Daughter to participate in the research. He/She will need to participate in two days training [for the SVI] during school hours in their school compound. The training will focus on the use of resources designed for enabling SVI to take active part in Science and Mathematics activities. Three Science and Mathematics lessons will also be observed to see how the SVI engage with the resources independently/confidently during the lessons. The students [one for SVI and one for sighted classmates] will also take part in 60minutes focus group discussions in their preferred place within their school compound after using the resources. This will enable me to find out their assessment of usefulness of the resources and suggestion that will bring a better usefulness. I also want to find out from the sighted classmates how it affects their own study. They would use pseudonyms during the focus group discussions to ensure confidentiality. I will like to use Camera to video record the interview and classroom activities to capture their engagement with the resources. Their faces will be blurred in the recording to ensure confidentiality but the recording will allow adequate documentation of data. It will be recorded in a way that will not disclose their identity They will not be identified in any way from the research reports, you can call or send email to me in case you want to withdraw within one month to the time of data collection and the data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored in a zipped folder protected with a strong password. The folder will only be available to me and my supervisor. The data will be retained according to University ethics for a period of ten years.

Their participation is important and will be highly appreciated. An informed consent form will be issued to all the concerned students, parents are therefore implored to sign the attached slip and return to me. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

Sariat Adelakun

[redacted]

Or my supervisor:

Dr Graeme Douglas

Email: [redacted]

Appendix IIId

STUDENTS INFORMATION SHEET [Sighted classmate] IN STUDY SCHOOLS

Hello!

My name is Adelakun Sariat Ajibola. I am conducting research at the University of Birmingham, UK investigating how to improve access of students with visual impairment (SVI) to Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit on participation and independence of students with visual impairment in Basic Science in South-Western Nigeria. You would agree with me that the world today is dominated by products of science and the Nigerian National policy on education proposes education for all irrespective of the disability. Realising the importance of science in Nations building, Nigerian government also launches equal educational opportunity for all its citizen and made admission to tertiary institutions to be in favour of science courses. Mathematics is also a compulsory requirement for admission to all tertiary Institution in Nigeria. Therefore, it is necessary to evaluate resources that could improve SVI's access to science and mathematics.

Please permit me to invite you to participate in the research as sighted classmates of the SVI. You will need to participate in 60minutes focus group interviews in your preferred place within your school compound after the SVI has used resources during lesson activities. This will enable me to find out your assessment of usefulness of the resources to the SVI and how their use of the resources affected you. Your suggestions that will bring better usefulness will be appreciated. You can use pseudonyms during the focus group discussions to ensure confidentiality. I will like to use Camera to video record the interview and classroom activities to capture the engagement of SVI with the resources and how you were affected. Your faces will be blurred in the recording to ensure confidentiality but the recording will allow adequate documentation of data. It will be recorded in a way that will not disclose your identity

You will not be identified in any way from the research reports, you can call or send email to me in case you want to withdraw within one month to the time of data collection and your data will be removed entirely. The information provided will be treated as confidential and will only be used for the purpose of the research. The data will be stored in a zipped folder protected with a strong password. The folder will only be available to me and my supervisor. The data will be retained according to University ethics for a period of ten years.

Your participation is important and will be highly appreciated. If you would like to see a summary of the results when they are available, or have any questions about this study at any stage, then feel free to contact me or my supervisor.

Sariat Adelakun

Or my supervisor:
Dr Graeme Douglas
Email:

Appendix IIIe

Teachers informed consent

Hello!

Who am I?I am Sariat Adelakun, a PhD student in the School of Education, University of Birmingham, UK. I am investigating how to improve access of students with visual impairment (SVI) to Basic Science/Mathematics in South-Western Nigeria. Specifically, I am evaluating the impact of Talking LabQuest, a product of Independence Science and a special STEM kit participation and independence of students with visual impairment in Basic Science/Mathematics in South-Western Nigeria. As a science/mathematics teacher in a mainstream classroomwith students with visual impairment, I would like to invite you as one of the participants for this research study.

My research topic:Science is one of the compulsory subjects in the nine year basic education in Nigeria and there are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in Science classes in particular. Knowledge of science enables individuals to eliminate misconceptions surrounding happenings in the universe and a visually impaired also need to be able to explain, appreciate and contribute to happening around in this world that is dominated with products of science. It is therefore very important to evaluate resources in use in some parts of the world with an intention to bring about a change

How can you help me? Your involvement will require participation in e-mail interviews, and a training session on the use of Talking LabQuest and special STEM Kit resources for teaching Basic Science in a mainstream classroom. Permit me also to observe your Basic Science lessons to find out the impact of the resources on participation and independence of SVI in science and Mathematics activities. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions and you will not be identified in the recordings.

Your rights:You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the study by calling me or through email within one month to the time of data collection. In case of withdrawal, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details:For any information and queries regarding my research project and the findings, you are free to contact me or my supervisor:

Email:
Research supervisors:
Dr Graeme Douglas
Email:

NOTE
PLEASE KEEP THE CONSENT FORM, SIGN THE ATTACHED SLIP AND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU
Sariat

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed if the withdrawal is within one month to the time of data collection.

Name:------------------------------------Signature:--------------------------------

Appendix IIIF

Students informed Consent [SVI]

(Was presented in Braille and enlarged font for blind and low vision participants respectively added to the normal print copy for their parents)

Hello!

Who am I?I am Sariat Adelakun, a/PhD student in the School of Education, University of Birmingham, UK. I am evaluating the impact of Talking LabQuest and special STEM Kit on participation, and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. As a student with visual impairment,I would like to invite you as one of the participants for this research study.

My research topic: All round education is a right of every citizen. As you know science is one of the compulsory subjects in the basic education level in Nigeria. There are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in science classes in particular. It is therefore very important to evaluate impact of Talking LabQuest and special STEM Kit that could improve SVI's access to science and Mathematics

How can you help me? Your involvement will require participation in focus group interviews to be able to assess the resources. I also need to observe your basic science and Mathematics lessons. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions and you will not be identified in the recordings.

Your rights: You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the study within one month to the date of data collection. In case of withdrawal, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisors:

Email:

Research supervisor:
Dr Graeme Douglas Email:

NOTE
PLEASE KEEP THE CONSENT FORM AND SIGN THE ATTACHED SLIP AND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU
Sariat

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed if the withdrawal is within one month to the time of data collection.

Name:-----------------------------------Signature:--------------------------------

Appendix IIIg

Students informed Consent [Sighted classmates]

(Was presented for your parents if you are under 18years. Let your parent read and sign the attached slip. Return signed slip if your parent consent to your participation)

Hello!

Who am I? I am Sariat Adelakun, a PhD student in the School of Education, University of Birmingham, UK. I am evaluating the impact of Talking LabQuest and special STEM Kit on participation, and independence of students with visual impairment in Basic Science and Mathematics in South-Western Nigeria. As a student with visual impairment, I would like to invite you as one of the participants for this research study.

My research topic: All round education is a right of every citizen. As you know science is one of the compulsory subjects in the basic education level in Nigeria. There are great difficulties relating to the inclusion of children with visual impairment in the curriculum and to involvement in science classes in particular. It is therefore very important to evaluate impact of Talking LabQuest and special STEM Kit that could improve SVI's access to science and mathematics

How can you help me? Your involvement will require participation in focus group interviews to be able to assess the resources. I also need to observe your basic science and mathematics lessons. I also want to inform you that I need audio-visual recordings to enable me to capture necessary bits to guide my conclusions you will not be identified in the recordings.

Your rights: You do not have to collaborate in this research study. It is completely voluntary and you can easily refuse to participate in this research study without giving me any reason. As a participant you may also withdraw from the study within one month to the date of data collection. In case of withdrawal, the given data and information will be removed. I must assure you that the information collected will be kept confidential. Your names will not be reflected in the research report to ensure complete anonymity.

My contact details: For any information and queries regarding my research project and the findings, you are free to contact me or my supervisors:

Email: [redacted]
Research supervisor:
Dr Graeme Douglas
Email: [redacted]
NOTE
PLEASE KEEP THE CONSENT FORM, SIGN THE ATTACHED SLIP AND RETURN IT TO ME TO INDICATE YOUR ACCEPTANCE TO PARTICIPATE. THANK YOU

Reply slip:

I agree to participate in this research study. I have read the complete information given in the consent form and I understand that my given information will be kept confidential and will only be used for the purpose of this research study. I also understand that despite my agreement to participate, I can withdraw from the research at any time without giving reason, and my data will be removed if the withdrawal is within one month to the time of data collection.

Name:------------------------------------Signature:--------------------------------

Appendix IVa

Observation Schedule

Study school 1

Name of School……………………………………………………………………

Class Observed……………………………………………………………………

Subject …………………………………………………………………………..…

SVI
identity……………………………………………………………....Pseudonym

Name and Age of the SVI … ……………………………………….……………

SVI condition of visual impairment……………. …………………………………

Onset of visual impairment………………..………………..…………………

Any other disability……………… ……………………………………………………

Brief description of previous encounter with Mathematics/Science ………………

……………………………………………..…………………………………

Technology/resources already in use to learn Mathematics/Science.

…………………………………………………………………………………………

What other resources are you familiar with……………………………………

Teachers Qualification ………………………………..………………….

Teachers years of experience ……………………..………………………..

Role played by the specialist teacher (s) ………..……………………….

Qualification of the specialist teacher ………………………………………….

Any disability [teachers eyes condition……………………………………………

Time	**Activity Record (including SVI engagement)**	**Independence**	**Support**	**Resources**
1				
2				
3				

4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				

19				
20				
21				
22				
23				
24				
25				
26				
27				
28				
29				
30				

Appendix IVb

Focus group guides for the SVI

Theme / topic	**Question**	**Follow-up / prompts**	**Probes**	**Notes**
Introduction / engagement	I'm interested in Science and Mathematics lessons. To get the discussion going, can each of you in turn tell me something about your favourite part of these lessons.	N/A	N/A	
Reaction / recollection to Talking LabQuest and special STEM kit	Do you remember using the LabQuest? What of special STEM kit functionality? Can you tell me about that?	What did it do? Did you like it?	Tell me more about that… Is there anything else you remember? How?	
SVI engagement	Do you think the LabQuest and special STEM kit helped you (the SVI) learn about science / mathematics?	In what way? Why? How could it help more?		
Effect of the Talking LabQuest and special STEM kit on the understanding	How did the LabQuest and special STEM kit functionality affects your understanding?	Can you mention specific usefulness	Tell me more about that… Is there anything else	

Theme / topic	**Question**	**Follow-up / prompts**	**Probes**	**Notes**
of the lessons			you remember…	
Reaction / recollection to Talking LabQuest and special STEM kit	Do you remember using the LabQuest? Can you tell me about that?	Can you mention specific usefulness	Tell me more? Did you like it?	
Reaction / recollection to Talking LabQuest and special STEM kit	Do you remember using the special STEM kit? Can you tell me about that?	What did it do? Did you like it?		
With or without	Can you compare your understanding of the lessons with LabQuest and lessons without it?	Which did your prefer? Why? Which did you think the SVI prefer? Why?	Give me specific example	With or without
With or without	Can you compare your understanding of the lessons with special STEM kit and lessons without it?	Which did your prefer? Why? Which did you think the SVI prefer? Why?	Give example of what happened in the classroom/laboratory.	With or without
General comment	Is there anything you will like to say about the resources that we have not mentioned?	Any other contribution or suggestion?		

Theme / topic	**Question**	**Follow-up / prompts**	**Probes**	**Notes**
Thank you for the contribution				

Appendix IVc

Focus group guides for the sighted students

Theme / topic	**Question**	**Follow-up / prompts**	**Probes**	**Field Notes**
Introduction / engagement	I'm interested in discussing with you about Science and Mathematics lessons. To get the discussion going, can each of you in turn tell me something about your favourite part of these lessons.	N/A	N/A	
Reaction / recollection to Talking LabQuest	Do you remember seeing the SVI using the LabQuest functionality? Can you tell me about that?	What did it do? Did you like it? Does it affect the entire class positively or negatively	Tell me more about that… Is there anything else you remember…	
Reaction / recollection to special STEM kit	Do you remember seeing the SVI using the special STEM kit? Can you tell me about that?	What did it do? Did you like it? Does it affect the entire class positively or negatively	Tell me more about that… Is there anything else you remember…	
SVI engagement	Do you think the LabQuest helped the SVI learn about science?	In what way? Why?		

Theme / topic	Question	Follow-up / prompts	Probes	Field Notes
	What of mathematics?	How could it help more?		
SVI engagement	Do you think the special STEM kit helped the SVI more involved in science? What of mathematics?	In what way? Why? How could it help more?		
With or without	Can you compare their participation in the lessons with LabQuest and lessons without it?	Which did your prefer? Why? Which did you think the SVI prefer? Why?		
With or without	Can you compare their participation in the lessons with special STEM kit and lessons without it?	Which did you prefer? Why? Which did you think the SVI prefer? Why?		
Effect on sighted	What other things is in your mind about the resources? How are you affected with the use of the resources?	Any effect on your understanding of the lessons? Positive? Negative? General		

Appendix IVd

E mail Schedule

Theme / issue	Question	Responses
Opening / General reaction	I want to ask about your experiences of using the special STEM kit and Talking LabQuest resources. 1. Please describe your experience with the tools. 2. Having used the resources, comment on the usefulness or otherwise of each of the resources. 3. Consider teaching the same lesson with and without the tools – in what ways have the tools enhanced or detracted from your teaching?	
Impact upon visually impaired students	Here I'm interested in the impact the resources have had on the learning and engagement of the students with visual impairment. 1. Did you notice any change in the SVI participation during the Basic science/Mathematics activities when the resources were used? If so, can you describe the change (s) – ideally give examples for the pupils you teach. 2. Please tell me about the strengths and weaknesses of the resources for increasing the participation of the SVI in Science/Mathematics lessons: Strengths (what worked):............ Weaknesses (what didn't work,	

	what could be imporved):	
Impact upon sighted peers and the class as a whole	Here I'm interested in the impact the resources have had on the learning and engagement of the sighted students. 1. How do you think the sighted partners feel about the use of Talking LabQuest by the SVI, How are they affected? 2. How are they affected with the use of special STEM kit?	

Appendix Va

Tasks given in classroom and laboratory activities in study school 1

1. Arrangement of the tiles on the metallic board
   i. How fast was it done
   ii. Was it easily retrievable to him/her
   iii. Does it consider working space
2. 4X = 80 ;
   Steps:

   i. 4x = 80
   ii. x = 80/4
   iii. x = 20
3. 3x + 6 = 3
   Steps:

   i. 3x + 6 = 3
   ii. 3x = 3 – 6
   iii. 3x = -3
   iv. x = -3/3

4. Fix the graph on the metallic board
   i. Appropriately fixed with 4 small stronger magnet
   ii. Supported to fix with the 4 strong magnet
5. Form a table of y when x=1 to 4 if y=2x
   Steps:

x	1	2	3	4
y	2	4	6	8

   Is it right or wrong

6. Plot the graph of y = 2x
   Steps:

   i. Correct label of x axis
   ii. Correct label of y axis
   iii. Correct plotting of points (readings)
   iv. Fairly joined points with wikki stix
7. Measure the temperature of liquid in Conical flask labelled A
   Steps:

i. Connect the temperature to the TLQ
ii. Wait for the TLQ to be ready/navigate to sensor page
iii. Dip the other end in the liquid (stir if necessary)
iv. Press the data collection button
v. Follow the reading (either listen or read on the screen)
vi. Save the data on the TLQ

8. Measure the temperature of liquid in Conical flask labelled B
   i. Connect the temperature probe to the TLQ
   ii. Wait for the TLQ to be ready/navigate to sensor page
   iii. Dip the other end in the liquid (stir if necessary)/ pour the salt and stir continuously
   iv. Press the data collection button
   v. Follow the reading (either listen or read on the screen)
   vi. Save the data on the TLQ

9. Measure the pH of sample A
   i. Connect the Sensor to the TLQ
   ii. Wait for the TLQ to be ready/navigate it to sensor page
   iii. Dip the Sensor in the liquid/pour the salt and stir continuously
   iv. Press the data collection button
   vii. Follow the readings (either listen or read on the screen)
   viii. Save the data on the TLQ
   v. Hand over the equipment to the next person in the group
10. Measure the pH of sample B
   i. Connect the Sensor to the TLQ
   ii. Wait for the TLQ to be ready/navigate it to sensor page
   iii. Dip the Sensor in the liquid/pour the salt and stir continuously
   iv. Press the data collection button
   v. Follow the readings (either listen or read on the screen)
   vi. Save the data on the TLQ
   vii. Hand over the equipment to the next person in the group

Appendix Vb

Ask for SVI in study school 2

Tasks given in classroom and laboratory activities in study school 2

Part 1 JSS 1 Mathematics: Addition, subtraction, multiplication, division and simple equation

11. Arrangement of the tiles on the metallic board
    - iv. How fast was the tiles arranged on the metallic board
    - v. Was the tiles easily retrievable to him/her
    - vi. Does the arrangement left enough space for working space on the board

12. 45 + 35 =

    Steps:

    - iv. 45 + 35 =
    - v. 40+5+30+5=
    - vi. 70+10=80

13. 230 + 480 =

    Steps:

    - v. 200 + 30 + 400 + 80 =
    - vi. 200 + 400 + 30 + 80 =
    - vii. 600 + 110 = 710

14. 4x + 20 =

    4x = -20

    x = -5

15. 3x + 2x = 25

    5x = 25

    x = 5

16. 4x + 3x + 8y – 2y

7x + 6y

Part 2 for JSS 3

17. Measure the temperature of liquid in Conical flask labelled A
    Steps:

    vii. Connect the temperature to the TLQ
    viii. Wait for the TLQ to be ready/navigate to sensor page
    ix. Dip the other end in the liquid (stir if necessary)
    x. Press the data collection button
    xi. Follow the reading (either listen or read on the screen)
    xii. Save the data on the TLQ

18. Measure the temperature of liquid in Conical flask labelled B
    ix. Connect the temperature probe to the TLQ
    x. Wait for the TLQ to be ready/navigate to sensor page
    xi. Dip the other end in the liquid
    xii. Press the data collection button
    xiii. Follow the reading (either listen or read on the screen)
    xiv. Save the data on the TLQ

19. Measure the pH of sample A
    vi. Connect the Sensor to the TLQ
    vii. Wait for the TLQ to be ready/navigate it to sensor page
    viii. Dip the Sensor in the liquid
    ix. Press the data collection button
    x. Follow the readings (either listen or read on the screen)
    xi. Save the data on the TLQ
    xii. Hand over the equipment to the next person in the group
20. Measure the pH of sample B
    viii. Connect the Sensor to the TLQ
    ix. Wait for the TLQ to be ready/navigate it to sensor page
    x. Dip the Sensor in the liquid
    xi. Press the data collection button
    xii. Follow the readings (either listen or read on the screen)
    xiii. Save the data on the TLQ
    xiv. Hand over the equipment to the next person in the group

Appendix VI

ECC assessment format

Skills	**Description**	**Statements**	**Rating (Circle the most appropriate)**	**Comments**
Compensatory skills	Students level of reading within mainstream settings	Read Braille orally at ____wpm	T F N	
		Access information in the library or textbook on par with peers	T F N	
		Access a variety of print format	T F N	
		Demonstrate basic map, chart and graph reading	T F N	
		Use variety of reading devices	T F N	
Compensatory skills	Students level of personal academic organisation	Student is prepared as activity begins	T F N	
		Keep a schedule of activities for the day week and month	T F N	
		Maintain personal address phone	T F N	
		Labels, organises and maintains personal belongings	T F N	
		Plans work schedule for studies and class assignment	T F N	
Independent living skills	Level of Students participation in his/her class	Don't participate in class activities	T F N	
		Don't talk to people other than the SVI	T F N	
		Share his items with friends	T F N	
Social skills	Quality of students social interaction	Uses correct telephone etiquette	T F N	
		Politely request assistance from classmates	T F N	

Skills	Description	Statements	Rating (Circle the most appropriate)	Comments
Social skills	Students participation during small and large group activities	Initiates conversation with new people	T F N	
		Participates in school activities	T F N	
		Cooperates in team work/activity	T F N	
Independent Living	Level of assertiveness or passivity in the classroom	Answer questions in the class	T F N	
		Participate in group work	T F N	
		Communicate with sighted peers during lesson	T F N	
		Seek assistance from friends when necessary	T F N	
Self determination	How student handle discouragement or frustration or failure	Articulates personal goals	T F N	
		Role plays in the classroom	T F N	
		List possibilities for future employment	T F N	
		Describe jobs done by some familiar adults	T F N	
		Ability to convince others on his future plans	T F N	
		Politely reject unnecessary assistance	T F N	
Recreation / Leisure	Students posture and physical support during activities	List some hobbies and leisure activities he can participate	T F N	
		Ask for assistance in a socially acceptable manner	T F N	
		List social activities in the school	T F N	

Skills	Description	Statements	Rating (Circle the most appropriate)	Comments
		Participate in school games	T F N	
		Understand games strategies	T F N	
		Adapt activities	T F N	
Independent living skills	Students level of independence travel within the classroom and the school area	Developed good eating habit	T F N	
		Pour liquids with minimal spill	T F N	
		Buy things and take correct change	T F N	
		Observe personal safety	T F N	
Use of Assistive Technology	Student skill level in making use of technology	Use problem solving methods when equipment malfunctions	T F N	
		Use talking devises effectively (thermometer, weighing balance, kettle)	T F N	
		Demonstrates basic knowledge of spatial concept (top, bottom, left , right)	T F N	
		Use Perkins Brailler adequately	T F N	
		Use slate and stylus efficiently	T F N	
		Record classwork with tape/audio recorder	T F N	
		Retrieve recorded lessons and brailled successfully	T F N	
		Use audio books	T F N	

Skills	**Description**	**Statements**	**Rating (Circle the most appropriate)**	**Comments**
		Competence in keyboarding ……wpm	T F N	
		Use screen reading program comfortably	T F N	
		Don’t know what is reading programme software	T F N	
		Competent in Microsoft word /excel program (have minimal computer use skill)	T F N	
Sensory efficiency skills		Observe eye-hand coordination correctly	T F N	
Career education	Evidence of students understanding of jobs people do	Accept and respond to suggestions	T F N	
		Carry out class assignment as expected (Timely)	T F N	
		Organise task toward meeting goals	T F N	
		Identify work done by school staff	T F N	
		Able to list job of family members	T F N	
		Able to differentiate the jobs identified		

Appendix VII

Certificate of incorporation of the NGO

Appendix IX

Paper presented at Pixel Conference

Inspirations from Scientists and Engineers Who Are Blind and Visually Impaired - Lessons to Initiate New Direction for Science Education of Blind Students in Nigeria

Sariat Adelakun

University of Birmingham, Birmingham. United Kingdom

;

Abstract

Preventing students with visual impairment (SVI) from participating in Science and Mathematics lessons is denying them the opportunity of equal educational opportunity promised by the Federal Government of Nigeria. It is against the Education for all Acts (1990) and No child left behind act (2002) which Nigeria is a signatory. Denying SVI this opportunity put them at a risk of lonely, isolated and unproductive lives (Texas school for the blind and visually impaired). Not only is the possibility of producing future scientist who have impaired vision but the contribution of science in making the blind or visually impaired live a fulfilled life cannot be overstressed. To John Gardener, a blind Physicist it is an awful thing to do to a kid, just wave a course because he cannot learn it. This paper showcase inspirations from scientists who are blind or visually impaired, their contributions in the field and specific techniques used that enabled them to do science are reviewed to serve as direction for Nigeria. For instance, Supalo, a professor of Chemistry employ paid readers to draw responses on all assessment, emphasise the need to develop habit of thinking creatively, know what adaptive technology is available and be good in problem solving skills. Gary Vermeiji said the prevailing attitudes about science and the blind must be reformed. Scientifically inclined blind should not be steered toward the social sciences away from fields in which laboratory and outdoor studies are important. He believes the chief factor holding the blind back from science is ignorance.

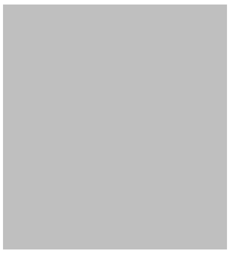
1. Introduction

Education in the Nigeria National Policy on Education is seen as instrument par excellence for effecting individual and national development. The Educational policies in Nigeria like other countries are driven by the international agreement or acts. For example, the right of all Nigerian to education is provided in section 18 of the 1999 constitution. Similarly, the formulation of the National Policy on education in 1977 and the repeated revision of the in 1981,1989,2004 and 2008 is influenced by the Education for all Acts, the IDEA etc Section 8 of the 1977 and revised 1981 and 1989 education policy Provision is devoted to education of children with special educational needs and more elaborate sections are provided in the 2004 and 2008 revised policy. The latest special provision was influenced by the enactment of Child Right Act in 2003 which was enacted into law in 2004 using Universal Basic Education (UBE) to provide free, compulsory 9 years basic education for all Nigerian of school age. Nigeria is moving in the right direction. However, students with visual impairment are affected greatly by attitude of educators who preconceive without adequate knowledge what the SVI can and cannot do. [1][2]

Can students with visual impairment become scientist? Can they participate and contribute meaningfully in science disciplines? Are there role models? What can Nigeria Government, educators, teacher trainers, family members and course mate gain from the experience of the role models? Is it possible in Nigeria? Has anyone in Nigeria studied STEM discipline? What about the resources and logistics? These and other questions are the focus of this paper.

Many blind or visually impaired people have studied STEM courses. The scope of this paper cannot allow me to draw inspirations from many of them. I purposively selected few role model in STEM disciplines. A brief biography at least to show the onset of blindness, Specific inspirational quotes from the role models to show areas of importance to the SVI, their families, friends, school mate, Science teachers, TVI (Resource persons or specialists), Teacher trainers and the Government.

Fig 1 Professor Cary Supalo



1.2 Biography

Cary Supalo lost his eyesight in 1982 at a very young age of seven. He started as a business administration major at DeKalb's Northern Illinois University, later transferring to Purdue University to earn two bachelor's degrees, one in chemistry and one in communications, then went on to earn a Ph.D. in chemistry from Penn State University. He is a trained chemist. Along the way, he added majors in computer science, engineering and liberal arts. Cary Supalo is the founder and president of Independence Science, an access technology company that develops and distributes blind and low vision tools that increase students' access to hands-on experiences in the science, technology, engineering, and mathematics (STEM) classrooms.

1.3Quotes

Below are some of his sayings influenced by his experience:"I believe in a can-do attitude," said Supalo

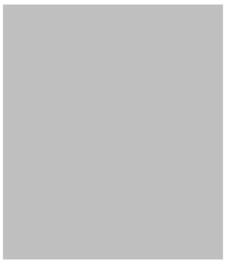
"I wasn't allowed to touch anything in high school," he said "We're not making these blind kids enjoy science," Supalo said. "The overall perception is that they cannot do what they need to do. That's where I come in."

I just want give back to the population that I am a part of," Cary says Lab experiments are commonly viewed as too difficult for someone with a visual impairment and thus a student is relegated to note taker or secretary." "My experience has taught me that blindness need not be a barrier in the pursuit of one's ambitions to achieve whatever goals he or she aspires to achieve."

Table 1 **Strategies**

S/N	Inspirations
1	Training for the TVI typically doesn't differ much from the training provided for a science teacher, despite their varying roles. Cary believes that an understanding of these roles is essential for a student to be successful in the science classroom. "The role of the TVI emphasizes how to adapt the concept for the student, but the TVI doesn't need to have a mastery of the curriculum,"
2	"The role of the science teacher, on the other hand, is just the opposite. They need to have a mastery of the science curriculum but don't necessarily need to know all the adaptations."
3	Through support from friends and faculty members at Purdue University, he was encouraged to study Chemistry

2 Lev Semenovich Pontryagin [3 September 1908 - 3 May 1988]



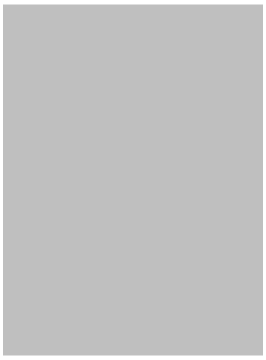
2.1Biography

He was born in Moscow and lost his eyesight due to a primus stove explosion when he was 14. Pontryagin attended the town school where the standard of education was well below that of the better schools but the family's poor circumstances put these well out of reach financially. Pontryagin received many honours for his work. He was elected to the Academy of Sciences in 1939, becoming a full member in 1959. In 1941 he was of one the first recipients of the Stalin prizes (later called the State Prizes). He was honoured in 1970 by being elected Vice-President of the International Mathematical Union [3]

Table 2 inspirations

S/N	**Inspirations**
1	Despite his blindness he was able to become one of the greatest mathematicians of the 20th century, partially with the help of his mother Tatyana Andreevna who read mathematical books and papers to him
2	But how does one read a mathematics paper without knowing any mathematics? Of course it is full of mysterious symbols and Tat'yana Andreevna, not knowing their mathematical meaning or name, could only describe them by their appearance. For example an intersection sign became a 'tails down' while a union symbol became a 'tails up'. If she read '*A* tails right *B*' then Pontryagin knew that *A* was a subset of *B*!

3 Geerat J. Vermeij a blind Biologist



3.1Biography

Gary became blind since age three, but he has made a career out of seeing things most people can't see. He has been a member of faculty of Department of Biology in Maryland University from 1977-1988. Currently, he is a Distinguished Professor of marine ecology and paleoecology in the Geography Department of the University of California. Dr. Vermeij has also been honored with numerous awards including the U.C. Davis Faculty Research Award in 2004, the Daniel Giraud Elliot Medal by the National Academy of Sciences in 2000, the Paleontological Society Medal in 1997, a $280,000 MacArthur Fellowship Award in 1992, and a Guggenheim Fellowship in 1975.

Table 3 Quotes/inspirations

1	"Blindness is a nuisance that can be largely overcome," Vermeij says. "It is not a disaster. It is not to be pitied or revered. It is just a condition that has to be dealt with as

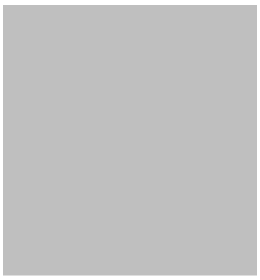
	you get on with life."
2	As at the time Gary was studying science, there's essentially nothing in Braille,"
3	“Most people who try to imagine what it's like to be blind think of blackness, and, you know, that's just not the right analogy. The world for me is not black. In fact, it's very much the opposite for me because I hear all kinds of wonderful sounds. I can feel all kinds of wonderful things. I smell wonderful things. I taste nice things. So for me, the world has not lost any of its beauty or its appeal or its challenge just because I happen to be blind”.
4	"One of the general sadness is that the blind are discouraged by presumably well-intentioned people from pursuing what they want to pursue”.
5	The biggest obstacle to him was when the state Agency for the blind declined to pay someone to read books about shells to him
6	"I see it as my main mission to be as successful as I can be at my chosen profession and that it represent real scientific accomplishment. If that rubs off on the blind, that's fine."
7	"They should have equal opportunity Nobody should be denied a chance at the fullest life possible by someone else's notion of what's good for them
8	"Many blind people feel themselves terribly inferior as a consequence of having been told that so many times. A very important first step is to make people feel it's okay to be blind."

4 Emmanuel Karemi Dinglip

Emmanuel a Nigerian became blind at the age of seven after measles attack He attended Gindiri School for the blind in Plateau State, Nigeria for his primary education. He also attended Boys Secondary School Gindiri for his secondary education. He made good grades in his secondary final examination. Emmanuel studied Mathematics at the University of Jos Nigeria and graduated with second class honours in the year 2000. He is currently working with the Federal Ministry of Education Headquarters, Abuja [2]

Though, much is not available in the literature on Emmanuel but his ability to study Mathematics in Nigeria when resources in schools cannot be compared with current situation in terms of quality and quantity worth commendation. He studied when equal education opportunity to all Nigerian citizens has not been enacted into law in Nigeria. This shows that SVI, teachers, teacher trainers and Government should take inspiration from this.

5 Abraham Nemeth



5.1Biography [16 October 1918-2 October 2013]

Abraham Nemeth, mathematician was born in New York. He was blind from birth. He attended regular public school as a totally blind child. He majored in psychology at Brooklyn College and received a master's degree from Columbia University and a PhD in mathematics from Wayne State University. The Nemeth Braille Code for Mathematics and Science Notation was published in 1952 and he also developed MathSpeak, a standard system of reading mathematical formulas out loud. This was a landmark step in the opportunity for blind students to engage in scientific studies.

He joined the department of mathematics at the University of Detroit In 1955, where he worked for thirty years. He was the chairman of the Michigan Commission for the Blind between 1991-1993. He received many awards like the Migel Medal, award by the American Foundation for the blind in 1999. The Creative Use of Braille Award from the American Printing House for the Blind in 2001, the Exemplary Advocate Award by the Division of Visual Impairments of the Council for Exceptional Children awarded him and also a co-recipient of the Dr. Jacob Bolotin award

Table 5 Inspirations

S/N	
1	His determination to pursue his love of math and science despite the lack of Braille materials in these fields led in 1952 to the creation of what is now known as the Nemeth Code for Mathematics and Science Notation. He was discouraged from studying Mathematics while in the college because it was assumed that a blind person would not be able to follow equations and calculations written on a blackboard
2	"to expect from a blind child what you expect from a sighted child."
3	His father walked with him on the streets to make him comfortable with his surroundings: "My father encouraged me to touch the raised letters on mailboxes, fire hydrants and police and fire call boxes. That's how I learned the letters of the alphabet."
4	Nemeth distinguished himself from many other blind people by being able to write visual print letters and mathematical symbols on paper and blackboards just like sighted people
5	He never had a guide dog and only rarely used a cane and believed that a blind person could master virtually any skill or discipline, no matter how technical

Conclusion:

There are lots of inspirations in the sayings and experiences of the role models discussed in this paper. The SVI should have high self-esteem, to believe in themselves and never yield to people discouraging them from achieving their maximum potentials.[2] The family members and the society at large should expect what they expect from the brilliant sighted from the SVI. The teachers should accommodate them in their classes.[1] Teacher trainers should inculcate the right trainings for the TVI/resource persons in schools and finally Nigerian Government should make available provisions in terms of assistive technology and other resources necessary to make their full inclusion in Science possible.

References

[1] Abilu, R. A. (2004) Tools for enhancing science Braille Notation Skills of teachers and service providers. Journal of the Association of libraries for the visually impaired (JAVL) 3 (1) 18-28

[2] Adelakun, S. A. (2013) *A directory of Visually Impaired professionals in the field of Science Tehnology, Engineering and Mathematics (STEM)*Offa: Adelodun Publishers

[3]http://www.blind.net/resources/employment/blind-professor-receives-macarthur-award.html#sthash.iGv59NH4.dpuf

[4]http://www.theepochtimes.com/n3/33576-blind-engineer-paves-the-way/#ixzz2q8ShbQaJ
[5]Coronado R. (1995) Blind Professor Receives Macarthur Award Copyright © Davis Professor Wins $280,000 as "Genius" National Federation of the Blind

[6]Sterling D. A. (2012) *Pure Energy Systems News* May 2, 2012

Appendix X

Experts seek greater participation in Mathematics, Sciences

By Josephine Oguntoyinbo

Preventing Students with Visual Impairment (SVIs) from participating in Science and Mathematics lessons have been described as denying them of equal educational opportunity promised by the Federal Government of Nigeria.