CHALLENGES OF TEACHING SCIENCE AND MATHEMATICS TO STUDENTS WITH VISUAL IMPAIRMENT: THE NEED FOR A DIRECTORATE OF RESOURCE CENTRE SERVICES

By
EMEKA D. OZOJI, Prof. mnae, fnaec, fpattean
University Of Jos
BERNADETTE E. OZOJI, Ph.D., mstan
Department of Science and Technology Education
University OF Jos **And**
ISUWA I. JURMANG Ph.D mnaec
Department of Special Education and
Rehabilitation Sciences
University of Jos

Abstract

In this paper, the authors discussed the challenges facing students with visual impairments (SVI) in the study of science, technology and mathematics (STM) from the perspectives of the SVI, the school/teachers and the classroom environment. These challenges were found to significantly impede their access to the study of STM. Specific ways to address these challenges from the home/parents, the SVI, and the school, were advanced. Above all, an all inclusive and super ordinate stratagem in the name of Directorate of Resource Centre Services (DRCS) was proposed as the key to open stress free access to every course that SVI wish to study in any post-secondary institution in this country. The DRCS underlying basis, objectives, rationale, location, policy formulation, human and equipment resources including the services it is expected to provide were specified. The authors conclude that the DRCS is an example of accommodation and best practice in special needs education and promises to liberalize access to qualitative higher education for SVI in the country.

Introduction

Challenges in the context of this paper refer to situations in the teaching-learning process which hinder students with visual impairment (SVI) in gaining and expressing knowledge in their chosen courses of study. The situations could be quite demanding, pose as a threat, and a barrier to attainment of set goals. They are action- provoking and push the school and the learner to seek alternatives, remedies, suggestions to clear the difficulties and enthrone teaching and learning access to the SVI. As long as the situations remain unattended to, so long will success in the educative process remain impaired and targets unmet.

Of all the subjects in the school curriculum, none is as dreaded by students as mathematics. This is followed by science subjects, especially physical sciences which are mystified and perceived as abstract and difficult. Considerable effort has been made by

relevant stakeholders to make the study of science and mathematics less dreaded in the schools. For instance, government agencies (e.g. Federal Ministry of Education and National Mathematical Centre); associations such as Science Teachers' Association of Nigeria and Mathematics Association of Nigeria; publishers such as Macmillan, have invested considerable resources in making the subjects appear likeable to students, to simplify their teaching and learning and to change the perception that STM are very difficult subjects. The extent these efforts are yielding positive changes remain to be seen in the face of massive students' failure in schools and public examinations (Bot &Timku. 2014; FME, 2006; Odili, 2006;).

The teaching and learning of STM inculcates in students important scientific attitudes, such as objectivity, open-mindedness, honesty in reporting scientific results, fastidiousness, and patience. Apart from this, students acquire thinking skills, such as reflective thinking, logical thinking etc, which will be beneficial to them throughout life. This is because these are the tools that will prepare them for decision-making, creativity, innovation and taking up their rightful positions in the society for national development. Ozoji (1996) noted that the idea of exposing children with visual impairment (CVI) to science experiences and instruction right from pre-school it is not necessarily to turn them into scientists per se but to provide them positive favourable scientific attitudes of "finding out" and "hands on" and to enable them raise questions about things that in intrigue them. Regrettably, SVI are known to have little or no access to the study of science and mathematics in Nigerian schools as important as the subjects are (Jurmang and Ajobiewe, 2009). This is at variance with the provision of the national policy on education which stipulates that basic education shall be free and compulsory for all children (FME, 2009). It is equally at variance with the goals of education for all (EFA).

Despite the indispensable role of science and mathematics in societal development, students' achievement in internal and external examinations is persistently poor and poses serious challenges to the realization to the objectives of the subject (Abakpa, 2011; Koruwa & Akimbote, 2014, Ozoji, 2010;). The chief examiner's report (West African Examinations Council, 2011) shows that students lack understanding of some science and mathematics concepts due to poor teaching methods. This may be true for the very few SVI in the nation's schools.

Students with visual impairment (SVI) suffer from some forms of visual loss leading some of them to retain visual perception to some degree while others to have no light perception (blindness). In most cases, the ability to see and reflect experiences linked to sight are compromised. Impact of visual loss on an individual is overwhelming making it second only to deafness as the most dreaded among the impairments. Visual impairment is associated with losses of various types. Loss of basic skills (such as mobility and techniques of daily living skills) and loss in communication (e.g. ease of written, spoken and informational programme) are the most critical.

The school has the primary obligation to teach all children including those with visual impairment all the subjects in the national curriculum including science, technology and mathematics (NPE, 2009). This has not been easy for the school partly

because most students perceive the subjects as abstract and difficult and would opt out of their study if given the opportunity. If this summarizes the perception of the sighted towards the study of STM then for their peers with visual limitations it is almost considered an impossible venture.

In this paper, the authors will attempt to look at the gamut of issues involved in teaching STM. Primarily, it will focus on the challenges encountered in teaching the subjects from the perspective of the students, the school/the teacher and in teaching the subjects. While the focus of discussion is the SVI in higher education, it is to be understood that if the lower levels of education do not encourage the study of science and mathematics and they do not transit students to secondary schools and beyond, non will be available for higher education. Therefore, the discussion is not going to be limited to higher education per se, but will touch on situations right from the home as long as they in one way or the other, have something to offer to or deny from the study of science and mathematics to SVI. The Directorate of Resource Centre Services (DRCS) was proposed as an all inclusive and super ordinate stratagem to deal with the issue of access to the study of STM by the SVI.

Challenges Faced by SVI

Students with visual impairments (SVI) have a limited window to access visual information in science and mathematics teaching and learning. Experience shows that about 80% of totality of learning is visually mediated. This is because vision is the primary system of sensory input for man. The SVI is therefore disadvantaged in accessing science and mathematics texts, laboratory apparatus and practical activities generally and the meaning constructed from auditory and tactile interpretation of texts lacks details that will facilitate a comprehensive understanding of the STM concepts in textbooks. Expressing science and mathematics knowledge depends on clear understanding of science and mathematics concepts and principles involved.

SVI right from basic education are disadvantaged in the study of science and mathematics. Jurmang and Ajobiewe's (2009) nationwide survey on SVI study of mathematics in special schools revealed that SVI neither study nor sit for mathematics in SSCE, and that most of the schools do not offer the subject. In most cases, they are excluded from mathematics classes because the teacher believes they lack the capacity to study it, Unfortunately, the SVI buy into the notion that they cannot study it and this becomes an institutionalized stereotype that negatively impinges on their resolve to study the subjects. There are few exceptions, however, to the non teaching of science and mathematics to the SVI. The School for Blind Children Gindiri offers mathematics because of availability of special resources in the Material Resource Center within the school. Their peers in regular schools do not appear to be so lucky.

There is a general resistance to the study of science and mathematics by SVI. One SVI was quoted complaining that "one mad" white woman in the school for blind children, Gindiri, was forcing them to study mathematics. Did she not know that blind children's brain is not for the study of mathematics?" Unfortunately, there is no scientific evidence to support the SVI claim which is widely accepted by many. Even though

children born blind have many gaps in their knowledge of the world, many SVI have gone ahead to disprove that claim by studying science and mathematics up to the university level. Experience has shown that intellectual development of SVI is not affected by visual impairment directly. However, it is believed that concept development is affected by restrictions that result from visual loss rather than visual loss itself. Many more would have achieved the same feat of studying science and mathematics if their environment was enabling and supportive and the SVI was strongly determined to study them despite the odds. In fact, a recent study by Jurmang (2014) showned that SVI can study geometry through the instrumentality of orientation and mobility exposure in a class. Their attitude towards the study of mathematics (geometry) was positively changed after exposure to the experimental intervention of selected concepts of orientation and mobility.

Students with visual impairment (SVI) as part of the school population, though insignificant in number, are included in the overall mathematics poor learning and achievement. In addition to these challenges, SVI encounter another set of challenges sui generi, which according to Kumar, Ramasamy & Stefanish (2001) include low teacher and parent expectation, fragmented resources, and teacher lack of professional preparations to use non-visual teaching methods. Jurmang (2014) added the challenge of non-provision of special teaching materials and skills as well as no mastery of the mathematical Braille notation code due to lack of training. The SVI are, therefore, victims of double jeopardy which significantly reduces their chance to study mathematics, and this invariably explains their absence in science based courses and careers.

Similarly, SVI, according to Access to be Blind, face challenges in accessing the world in three areas: the physical, the symbolic and the social world. The symbolic world represented by language exchange of ideas and information through symbols is a major challenge faced by SVI. Mathematics and science are subjects full of symbols, notations and formulae not visually accessible to most SVIs. Durre, (2010) identified the challenge of SVI not being able to follow lectures without verbal information in conjunction with the illustration and mathematical expression, translation of graphical and mathematical text is considerably more time consuming and difficult, and most are unable to use computer braille or Braille note taker for regular note taking.

School Based Challenges

One of the challenges facing the teaching of science and mathematics in schools is lack of teacher competences in the subjects. Pre-service teacher preparations do not sufficiently transfer the needed competencies to student teachers. Teachers must have mastery of the essential skills of blindness – Braille, non-visual teaching strategies and adaptive technologies. Many teachers are deficient in these skills and the equipment/gadgets for teaching the subject are lacking in most schools. Regular teachers do not have these competencies; their special teacher peers who have the skills are not yet part of the regular school teaching staff. They should be in the schools either as

resource room or support teachers if SVI in inclusive settings are to profit from the curriculum of the schools.

Schools often set low expectations for SVI which tend to lower their achievement. Schools are handicapped when it comes to providing special teachers and other resources essential for engaging SVI in science and mathematics teaching and learning. The authors recall an encounter in one inclusive junior secondary school in the federal capital territory Abuja where one SVI was found loitering about during a mathematics class. He complained there was no mathematics teacher for him and other students with visual impairment in the class and considered leaving the class a better option than the frustration of being in the class nobody bothers if he follows the lesson or not. The student added that SVI in that school do not take other science subjects. The school principal confirmed the student's story, but was quick to add that efforts to get the only SVI mathematics graduate currently working in the federal ministry of education re-posted to the school was yet to bear fruit. A visit to the resource room in the school by the authors revealed that there were imported assistive devices stored in the resource room but there were no specialist staff to use them as instructional resources.

According to WAEC as cited by Research Development Institute [RDII] (2013) WAEC result for Nigeria in 2013 had a total population of 1, 543, 683 candidates who registered, out of that population, only 117 candidates with visual impairment making 0.0075% for the examination registered. Lack of resource support must have contributed to this very little percentage of the candidates taking WAEC examinations. Similarly for more than ten years now the few candidates who write WAEC examinations, do not participate in Mathematics and science practicals (RDII).

The University of Jos a couple of years ago successfully graduated a SVI in mathematics through the resource support from the sister department of special education. Initially the mathematics department was very reluctant to admit the student who successfully finished his remedial programme in the university and wanted no other course except mathematics. It took the combined persuasion and assurances of the department of special education for the department to accept him on a trial basis. No other SVI has been admitted to study mathematics ever since then.

In 2014 the same mathematics department wrote the Department of Special Education and Rehabilitation Sciences to convey its disapproval to permit one B.Sc biology SVI student to write mathematics 101, arguing that the practice of reading questions to him and getting his answers recorded was not acceptable to the department apart from contravening the university Senate regulation on examinations. However, after several discussions between the two departments including intervention from the Directorate of Academic Planning and Development the student was officially administered an alternative to maths 101 to enable him graduate.

If these challenges are experienced in a university with special education resource support, one can imagine what the situation can be in any other institution where a SVI student has shown interest to study mathematics or other science based courses.

Challenges in Teaching Science and Mathematics To SVI

Another challenge a mathematics/Science teacher faces is how to convey visual concepts to students who have little or no vision. It requires teaching approaches that are non-visual based such as tactile representation, audio aids, tonal representations, and haptic devices. Teachers also encounter challenges of teaching concepts involving three dimensional objects (3-D), keeping up with advancement in science, mathematics and technology and transforming visual language of mathematics to the children (Kumar et al 2001).

The regular teacher alone cannot teach science and mathematics to SVI without human and technology support from special education specialist in science and mathematics education. It is a collaborative team teaching partnership. The special teacher operates from the resource room. The resource room and special teachers are not currently available in most schools in the country.

Two critical issues to teaching science and mathematics to SVI are how to gain science and mathematics knowledge and how to demonstrate this knowledge. (Durre 2010). Access to science and mathematics knowledge involves use of science/ mathematics braille codes, Nemeth, abacus, Taylor frame, cubarithm, scientific models and computer which are among the tools used to convey this knowledge to the SVI. The same tools are used to demonstrate science and mathematics knowledge during tests and examinations for teachers who do not read Braille. In these cases, the special teacher faces challenges of mastery of the tools. When the mathematics student earlier referred to was undergoing his studies, some mathematics symbols had to be sent overseas to get correct Braille codes for them. This led to delays and frustrations for both the teacher and the taught.

To overcome science and mathematics gaining knowledge challenges, materials can be provided in large print or Braille, in audio formats, via computers, and adaptive technologies that provide enlarged text/speech in Braille output. For demonstrating knowledge, worksheets, handout can be in large prints/Braille, audio format computers with extra time to compensate for slow completion of assessment/tests.

Most schools including universities do not have defined policy on accommodation and modification in teaching science and mathematics to SVI. Accommodation refers to changes in the programme that do not reduce standards but rather help provide access to the course content. It refers also to changes in the programme from the way things are typically done so that SVI can have equal opportunity to participate and be successful. Accommodation can be in the changes made in the way materials are presented (e.g. classroom recording of lecture by students, use of models and alternative to practical activities), changes in the way students demonstrate learning (e.g. modified assignment), changes in setting (preferential seating in the classroom), extra test time to compensate the tedious process of using non-print technologies to express knowledge of science and mathematics.

Modifications according to best practices lower learning expectation and should be used if this is the only way for the students to learn and be successful. A typical example includes altering assignments to make them easier.

In test taking even for standardized examinations such as Scholastic Assessment Test (SAT) in the USA accommodations are provided for SVI. If University of Jos had a policy on accommodations and modifications, the thinking of stopping the SVI from writing general mathematics 101 would not have arisen in the first place.

Availability of lecturer handouts in Braille or in audio format for SVI studying science and mathematics is critical to their success in schools; it takes considerable time and energy to Braille and record by the SVI except where a resource room provision makes it possible for them.

Suggestions For Improving access to Science And Mathematics Teaching

The various forms of challenges earlier discussed must be addressed through interventions in order to turn them into positive support to enhancing SVI capacity and opportunity to study science and mathematics.

Parent Intervention

Parents of SVI need custom made parent (tailor-made) education or information counseling that will enable them see their children as gifts to be treasured like their peers who need all forms of care and support to fill cognitive gaps that visual impairment occasions. They are to be encouraged to adopt best parenting practices that will enable their children reach their potentials in all aspects of development despite lack of sight. Over-protecting the SVI is not in the best interest of the child. It stunts creativity so much needed in stimulating cognitive development. This is the first basis for capacity build up to study science and mathematics later in life. Studies reveal that SVI reflect the same spectrum of cognitive abilities as do their peers without visual impairment, (Kumar et al 2001). Furthermore, science and mathematics concepts surround us and to help children gain a thorough understanding of concepts, hands-on experiences with real materials must be provided at home. Parents are expected to explain events structures, materials, furniture etc to children with visual impairment. This is to close up the gap in concept development highly facilitated by vision.

The SVI child needs help to overcome the crusted belief that he cannot study science and mathematics because of visual limitations. He needs to benefit from early childhood experiences during which he learns the pre-primary experiences in all subjects preparatory to basic education enrolment. He needs opportunities to boost his self-concept since visual impairment is a potential threat to development of positive self concept. A high self concept child is more likely able to cope with challenges imposed by visual impairment and has a high probability that he may be adventurous enough to like science and mathematics as subjects. Parents, teachers and significant others in the life of SVI can be self concept builders for SVI.

The areas in life that visual impairment imposes limitations, such as mobil control of the environment should offer the home and school the opportunity to deve programmes to address them. Not addressing them will make for an uneven developme

in the child – a situation that may not foster self-confidence, self-assertiveness and "out-goingness" in the child.

Attitude orientation of the society towards the SVI requires to be changed. People often discourage SVI from the study of science and mathematics. Helen Keller – the legendary American deaf-blind said the greatest problem of SVI is not the visual loss but the negative conception and attitudes of the society towards blindness and SVI. Attitudes as behaviour determiners contribute significantly to the lower expectances ascribed to SVI, particularly those that openly communicate uselessness and incapacity to study science and mathematics. The debilitating stereotypes that they cannot study these subjects must be debunked with evidence of SVI who have studied the subjects at higher education level. Jurmang reported that SVI exposed to orientation and mobility programme not only developed positive attitudes towards mathematics (Geometry) but. also achieved better than the control group in the geometry achievement test.

Special teacher preparation curriculum must be reviewed to give more slots to practicum for pre-service science students. The current subject combination with teaching subject should be sustained. The practical component of preparation ought to be strengthened. The value of teacher renewal in form of workshops must be recognized. Ozoji (1996) found one of such workshops on teaching science to SVI very impactful.

Special needs education is tending towards inclusive education where SVI will have the opportunity to study together with their sighted peers under the tutelage of the regular teacher in collaboration with the special teacher. If the quest for the study of science and mathematics by SVI must be achieved, special teachers and resource rooms must be conspicuous aspects of the schools. If this school type were to be available the SVI who left the mathematics class earlier referred to would have reconsidered his action. First, the special teacher provides from the resource room what he needs to remain in the mathematics class and what remains unattended to will be taken up in the resource room by the special teacher.

PROPOSAL FOR A DIRECTORATE OF RESOURCE CENTRE SERVICES (DRCS) FOR SVI IN HIGHER INSTITUTIONS

A Directorate of Resource Centre Services is a specially designated centre imbued with professionals and materials/equipment to provide backup support to SVI studying in higher institutions. Three issues underlie the Directorate of Resource Centre Services (DRCS) proposal in this paper.

i) The home, basic education and senior secondary schools are expected to have taken proactive measures to promote access to higher education for SVI respective of course of study.
ii) SVI who successfully complete and qualify for higher education will have a facilitated education with minimal stress irrespective of course of study and
iii) DRCS will stimulate quality mass education of SVI to actualize their higher education dream irrespective of course of study.

The DRCS specifications will be presented in outlines.

1) **Objectives**: To facilitate prompt completion of qualitative education through provision of essential network of support to SVI irrespective of course of study. Without this network of support access to certain courses would be impeded.
2) **Rationale**: Without essential network of human and equipment resources in selected higher institutions, it would be extremely difficult for SVI to pursue whatever course of interest. It is cost effective to have these resources established in designated institutions and to have SVI enroll only in the institutions where they can maximize the services of the center. With the support from the DRCS, SVI stand a higher chance to complete their course of study and with minimal stress but with higher learning outcomes.
3) **Locations**: Federal College of Education (Special) Oyo for NCE students; Kaduna Polytechnic for OND/HND students and University of Jos for university students. These institutions already have long standing departments of special education with core professionals to serve as seed staff for a smooth operation of the centre.
4) **Policy Formulation**: The affected supervising commissions (NCCE, NBTE & NUC) in association with the selected institutions are to draw up policy framework to guide the operations of DRCS in establishment, administration, funding, functions, etc, that will enable it operate in principles like the Directorate of General Studies in their institutions.
5) **Human Resources**: Core professionals in the education of SVI in collaboration with subject professionals in the course(s) the students are enrolled are critical to the success of DRCS. The core professionals Braille science and mathematics texts, produce tactile science and mathematics materials, record lecture materials, etc.
6) **Equipment Resources**: -
   - General technology in the education of SVI (e.g. abacus, Taylor frame etc)
   - Assistive/ Adaptive technology in the education of SVI (Screen readers, Video magnifier/word talk can read aloud any document written in word)
   - ICT (e.g. computer, Braille embossers, Braille keyboard)
   - Braille production equipment (e.g. computer Braille & Braille note taker).
   - Audio production equipment. (e.g. tape recorders, CDs etc)
   - Tactile production materials. (e.g. flying wheel, Braille mat. etc)
   - Models (two/three dimensional models)
   - Consumables, etc. (e.g. Braille paper, braillon etc)
7) **Services**: -
   - Support SVI in their studies (e.g. provide accommodation in their studies)
   - Production of tactile graphics (e.g. as often used in STM)
   - Print to Braille/Braille to print production (e.g. to handle lecture notes)
   - Counseling of SVI (e.g. personal, vocational, career counselling)

- Information dissemination about SVI (e.g. schools & DRSC can provide such advocacy)
- Accommodations and modifications (test taking, seat arrangement)
- Training volunteers interested in serving SVI (DRCS core staff can train volunteers to support SVI)
- Material procurement & production (e.g. purchasing modern equipment)
- Advice on universal design/modification of existing architectural designs. (e.g. professional consultation on universal designs etc)
- Library services, (e.g. current titles brailled or tape recorded)
- Workshops for stakeholders (regular/special teachers etc.) (e.g. core DRCS to run sensitization workshop/seminars for those who will work or collaborate with the centre)

Conclusion

In this country SVI pursue higher education with tears and many a time fail to earn comparable content in their courses because of the challenges in the process of their education. The issue of equity is important. It is not just students "rather certain students need specialized materials in order to have equitable opportunities to learn" (Kumar et al).

The DRCS proposal is intended to make higher education of SVI less traumatic but rich in experience garnered in this course of study. With appropriate resources and equipment, institutions can support SVI to engage meaningfully in all courses of their choice. Furthermore, the DRCS proposal has the potential to encourage diversification of courses and careers for SVI study. At the moment over 99% of SVI students are found in non-science courses. This does not present a true picture of the ability of SVI vis-à-vis science based courses and careers. It is just that enabling environment to enter science based disciplines is virtually not available. DRCS has the potential to clear this barrier thus open access to all fields of study for them. The authors recommend the establishment of DCRS in the designated institutions. The headship of these institutions are to work out modalities for the establishment of DCRS in their institutions

References

Abakpa, B. O. (2011). *Effects of mastery learning approach on senior secondary school students achievement and interest in geometry.* Unpublished Ph.D. Thesis, University of Agriculture, Makudi.

Access to the blind; http;//www.wordaccessfor the blind.org/node/103.

Balance for blind adults; http;//www.balance for the blind.org/living/vision/20looeshtml.

Bot, T. D. & Timku L. (2014). Performance profile of students in mathematics: Comment, remarks and implications towards development of Nigeria. *Nigerian Journal of Teacher Education and Teaching,* 12(1), 165 – 175.

Du .. I. (2010). *Success for blind students in mathematics & science: The importance of thinking outside the box.* Paper presented at the seventh international conference on higher education and disability; Innsbruce, Austria.

Federal Ministry of Education (2006). *Operation reach all secondary schools: Report on the state of secondary schools in Nigeria.* Abuja: Federal Inspectorate Services.

Federal Ministry of Education (2009). *National policy on education:* Lagos NERDC Press.

Jurmang, J. I. & Ajobiewe, T. (2009). *Assessment of the 9 year adopted basic education curriculum for learners with visual impairmen*t. Abuja: Nigeria Educational Research and Development Council (NERDC).

Jurmang, J. I. (2014). *Effects of applied orientation and mobility programme on attitude to and achievement in geometry of learners with visual impairment in North Central Nigeria.* Ongoing Ph.D research. Department of Special Education and Rehabilitation Sciences, Univ́ersity of Jos.

Kumar, D: Ramasamy, R & Stefanich, G.(2001). Science for students with visual impairment. *Electronic Journal of Science Education.* Retrieved htt;//ese.southwestern.edu/article/view/7658/5425

Odili, G. A. (2006). *Mathematics in Nigerian schools: A teaching perspective.* Lagos: Anachuna Education Books.

Okoruwa, T. O. & Akuibote, O.O. (2014). Effects of enhanced explicit teaching strategy on pupils' learning outcomes in primary science. *Journal of Science Teachers' Association of Nigeria*, 49(1), 1 – 18.

Ozoji, B. E. (2010). *Effects of concept mapping strategy and gender on students' cognitive development and performance in integrated science.* Unpublished Ph.D. thesis, University of Jos.

Ozoji, E. D. (1996). An evaluation of a workshop on teaching science to the visually impaired. *The Jos Journal of Educatio*n Vol 3, No.1, 43 – 48.

Research Development Institute Inc. (RDII) 2013. *Blind Students WAEC results.* Retrieved from the net on 2/9/2014.

WAEC (2011). *Chief examiner's report.* Lagos: Author.

Wale, M. (2012). *The role of science and technology in development: The key to Nigeria's transformation.* http://wale

Fig 1 Directorate of Resources Centre (DRC)

