Educational Research

Teaching life sciences to blind and visually impaired learners

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This study reports on the teaching of life sciences (biology) to blind and visually impaired learners in South Africa at 11 special schools with specific reference to the development of science process skills in outcomes-based classrooms. Individual structured interviews were conducted with nine science educators teaching at the different special schools and focus group interviews with ten Grade 12 learners taking a life science at each of the schools. The interviews were video- and audio-taped by sighted observers. The data was transcribed and the results coded and classified for interpretation purposes. The study revealed learners' difficulties in applying science process skills because of lack of vision, lack of confidence, lack of motivation, etc. For example, one such skill, namely 'tabulation', remains a problem to most blind learners. The blind learners were also very seldom engaged in practical work and field trips. Practical activities were limited to very simple and elementary exercises that provided little intellectual challenge and did not call for advanced problem-solving skills. Learners had limited access to computers, encyclopaedias, sources of reference and relevant publications. Educators did however apply cooperative learning strategies in schools where totally blind and partially-sighted shared the same learning environment.

Key words: Life sciences education; Blind and visually impaired learners; Science process skills; Inclusive education; Outcomes-based education

Introduction

Inclusive education is gaining momentum globally as a premise to the education of learners with special needs in mainstream classroom settings. This paper explains a number of problems pertaining to the teaching of life sciences to blind learners and its implications for an inclusive life science education policy. It expresses views and experiences of both learners and educators that the researchers interacted with during interviews. As there are differing types and degrees of visual impairments, this paper pays particular attention to the totally blind as the authors of this paper consider them to be the most vulnerable individuals in terms of the learning mediation of life sciences in an outcomes-based classroom.

Rationale and theoretical background

The paper reports on the outcomes of an investigation grounded in Jerome Bruner's theory of discovery learning (Carin and Sund, 1985; Van Rooyen and De Beer, 2007) and the syntactical structures of the science process skills reported by Carin and Sund (1985) and Van Aswegen et al (1993). The study was thirdly informed by Spady's notion of Outcomes-Based Education (OBE) (Spady, 1994) and Killen's operationalisation of OBE for classroom practices (Killen, 2000).

Aim and objectives

The following research questions were thought appropriate:

- How does the lack of visual ability during the learning mediation of biology and other life sciences impact on blind learners, life sciences educators, special schools and Outcomes-Based Education (OBE)?
- What would be the most appropriate learning mediation strategies and methods for teaching life sciences measured against the outlined national curriculum statements – and to what extent do educators use and apply these strategies and methods in special schools?
- To what extent do visually impaired learners achieve the learning outcomes specified for life-sciences/biology and which variables restrict effective teaching and learning in the life-sciences/biology classroom?
- What adaptations will therefore be required to traditional classroom practices in support of blind and visually-impaired learners in inclusive outcomes-based classrooms?

Having taken the problem statement and research questions into consideration, the aim of the investigation became to determine how the learning of the life sciences is facilitated (mediated) in special schools for blind learners. In addition, it aimed to establish how the lessons learnt from this experience could be implemented to the advantage of blind learners in the Senior Phase (Grades 8 and 9) and Further Education and Training Band (Grades 10-12) in inclusive outcomes-based education settings.

Visual impairment, teaching and learning

As far back as 1967, Haring and Schiefelbusch (1967) reported on various issues related to the education of visually-impaired learners. They focused primarily on the importance of vision and the mode of reading, and attempted (in classical positivist style) to illustrate how intelligence manifests itself in blind and visually-impaired learners as compared to the deaf. Their work emphasised the significance of blindness and

information processing and also illustrated the maximum utilisation of available sensory data during learning mediation as well as the translation of visual stimuli.

Freeman (1986) emphasised the importance of visual impairment as a handicap to gifted learners as follows:

"*(i)n them [visually impaired learners], conceptual development and abstract thinking seem to be delayed by the absence of visual stimulation or images; cognitive development occurs more slowly, and norms for chronological age groups are invalid*".

The significant role of visual stimuli as prerequisites for conceptual development in the facilitation/mediation of the subject content in general and the life sciences more specifically, has been recorded by many authors such as Falk (1980), Perkins (1974), Erwin *et al* (2001) and Fraser *et al* (1996). Figure 1 illustrates how multiple tactile stimuli supplement for the loss of sight, allowing learners to perceive size and shape three-dimensionally. However, blind learners are easily overwhelmed by the complexity of very 'full' or 'busy' diagrams and sketches. Blind learners need to be spatially orientated when 'feeling their way through', or reading, sketches and figures. Correction normally occurs when labels in Braille accompany diagrams, pictures, models and sketches.

Wittich and Schuller (1973) argued more than three decades ago that perception remains the foundation of learning. They stressed the fact that without a sufficient conceptual foundation, learning would be severely impaired and thinking would be severely limited (1973). However, it should also be taken into consideration that various developments in technology have significantly contributed, and still do, towards improving the plight of the visually impaired in the facilitation/mediation of learning.

Disabled learners and in particular blind and visually-impaired learners require and deserve specific strategies that address their unique learning mediation needs during the facilitation of life sciences. Jurmang (2004) noted that

"*(t)he fundamental principles of teaching have not changed, approaches to an individual child must be adapted to take account of that child's special needs. When working with children that have sensory impairment … the teacher must understand the significance of all these factors and create a favourable climate for learning.*"

On the other hand, Paul (2004) in regard to specialist programmes argued as follows:

"*(w)e need to look at introducing specialist programmes of these professionals to create a well trained pool of human resource.*"

In instances where specialised education and support systems are not in place, effective advocacy, professional advice and technical assistance will not prevail. Furthermore, the goal of equal participation by blind and visually-impaired learners, and the right to be mediated by educators who fully know and understand them better, cannot be achieved.

It is generally accepted that with the loss or absence of vision, the amount of sensory data available to the learner is reduced (Haring and Schiefelbusch, 1967). It is for this reason that the teaching and learning of the blind and visually impaired have to be firmly grounded in a multi-sensory approach as illustrated in Figure 1 (Erwin et al, 2001).

Learning mediation aids such as computers with speech (JAWS), interfaced speech synthesisers, closed-circuit television (CCTV), taped materials, reading machines, talking machines, hand-held magnifiers, Braille text, talking calculators,

Figure 1. Combining three-dimensional models with embossed 'Zytec' sketches labelled in Braille as a learning strategy.

sound sonification, auditory analogues of visualisation, instruments with auditory (and not visual) readings, touch and voice-based interfaces, touch and large print components have become standard equipment for the teaching of the blind and visually impaired (Kumagai, 1995; Trief and Feeney, 2003; Collette and Chiappetta, 1986; Siekierska *et al*, 2003). Burke (2001) maintains that "(e)ffective access to print is a matter of serious concern to every person who must do significant amounts of reading but who does not see print easily." Due to that, a number of blind learners who are likely to learn biology or any other life science subject are severely limited. Maguvhe (2003) argued that blind individuals, like any other person, are passionate about access to print, because it fulfils, rewards and satisfies when one is able to get – without difficulty – what he wants from the vast store of published work whether instructional, cultural, recreational, *etc*.

Adapting the curriculum

Any curriculum that is not learner-based and learner-paced will hinder the blind and visually-impaired learner from learning and actively participating in the learning mediation to her or his full potential. Educators are not aware of what should be done to accommodate blind and visually-impaired learners during the acquisition of Science Process Skills and/or assessment. Due to that, they discourage blind learners to take or consider science-related subjects as curriculum choices.

The following alternative approaches to curriculum adaptation and delivery have been applied to the teaching of blind and visually-impaired learners:

- setting a substitute task of similar scope and demand
- replacing one impossible or unfriendly task with a task of a different kind
- allowing the learner to undertake the task at a later date
- using another planned task to assess more outcomes or aspects of outcomes than originally intended
- giving the learner concessions (extra time) to complete a task
- using technology, aides or other special arrangements to undertake assessment tasks
- using an estimate based on other assessments or work completed by the learner (in circumstances where the above provisions are not feasible or reasonable)
- considering the format in which the task is presented,

e.g. the complexity of graphs, diagrams, tables, illustrations, experiments, cartoons, etc.

Research strategies applied during the investigation

The research sample

Nine educators and 45 learners from nine special schools for blind and visually-impaired learners in South Africa were interviewed through the use of qualitative inquiry methods. There are 20 schools with sections for blind and visually-impaired learners in South Africa and a sample of nine schools was drawn from the list. Semi-structured interviews as well as follow-up telephone interviews were used to get responses to various questions. The classroom activities were videotaped. During the interview, the researchers took notes reflecting respondents' personal views. Semi-structured interviews helped the researchers in capturing the attitudes and opinions of respondents during the course of the investigation. In addition, semi-structured interviews offered the researchers the opportunity to pose follow-up questions for further clarification.

Data collection and analysis

The fieldwork commenced during the second quarter (April) of the academic year. Each educator interview lasted for approximately 40 minutes followed by focus group interviews involving a group of five learners from each of the nine participating schools. The interviews were transcribed after which each transcription was coded and the responses categorised. The results capture the main findings that emerged from the coding and categorisation of the responses.

Results

Opinions regarding teacher training

One is of the view that education authorities and institutions of higher learning are doing very little to bridge the training gap between regular and special educators. Most institutions of higher learning have not introduced courses in the facilitation of learning to blind learners. This implies that those educators are inadequately skilled and remain poorly motivated in teaching at special schools. Student teachers (beginner educators) should be placed at inclusive or special schools for the blind to acquire experience on how to mediate or facilitate learning to blind and visually-impaired learners. The authors argued (Pauw, 1984, 1991; Spungin, 1977; Mani, 2000; Mason, 2000; and the Norms and Standards of Educators, 2000) that educator training is necessary for educators to understand the educational needs of learners. Abner and Lahm (2002) stated that "[t]o provide high-quality services and instruction, it is vital that certified teachers of students with visual impairments be well versed in the selection and application of current access technology." They argued further that to benefit from assistive technology, "… students who are visually impaired must have contact with dynamic teachers who have sufficient knowledge and skills in the use of technology."

Perceptions towards blind learners learning science subjects

It has often been argued that educators' negative perceptions towards blind and visually-impaired learners stem from factors such as educators' lack of confidence and ability to teach these children. As a result, such educators with pessimistic attitudes and experiences will beget more negative attitudes in such learners. Higgins and Ballard (2000), regarding negative attitudes, argued that what individuals like to think of as their attitudes, their values, their actions are in fact public rule systems or codes which define all possible modes of thought and action.

Prejudices towards the teaching of blind and visually impaired learners

The researchers are of the opinion that unnecessary demands, unfamiliar surroundings, an inflexible curriculum and inflexible assessment standards are prejudicial factors resulting in ineffective learning of persons with visual impairments. Authors such as Van Huijgevoort (2002), Charles and Yewpick Lee (2003) and Mani (2000) support this notion. According to Van Huijgevoort (2002), "[p]eople are limited not only by physical barriers, but by the attitudes of others." The author further argued, "[s]tigmatisation is an important factor in a person becoming … isolated." Prejudices may put blind learners at risk of isolation, possessing few friends and inadequate social skills.

Unique needs of blind and visually-impaired learners

Blind and visually-impaired learners, like any other disabled learner, have their unique needs. Though it is difficult to meet and satisfy these during the teaching and learning mediation of biology, special and inclusive schools should do whatever is possible to meet them in order to reasonably accommodate learners. Depending on the degree of blindness, some blind and visually-impaired learners need computer devices with display magnification software.

Observations and practical work

Blind learners battle with observations during the mediation of life sciences due to the fact that observation activities are less meaningful and less motivating to them. Jurmang (2004) advised that "(a)ctivities in the process need to be meaningful and motivating." They become totally excluded from the acquisition of valuable information when they do not receive explanations and interpretations from educators and fellow learners.

Based on sound evidence, the authors argue that very few blind learners currently do, for example, physiology up to grade 12. Access to the learning mediation of biology is also limited. This supports the argument that the learning mediation of biology depends on one's visual ability, thus making it difficult for blind learners to access information through visual observation. The first Working Session on the National Working Group on Curriculum Adaptation (2003) stated that "[o]bserving is a good means for gathering information. Traditionally, 'observing' has meant that learners watch what the educator is doing and then copy or model the same. A learner-centred approach to observation would require that learners are expected to analyse their observation…." The teaching of visually-impaired (partially sighted) learners remains highly individualised where written work and drawings done by the teacher are recorded and transmitted to personal workstation as illustrated in Figure 2.

Lack of visual ability deprives blind learners of the enjoyment and the advantage of observation. Borg (1987) indicated that observational processes are essential in enabling individuals to collect direct information. This means that blind learners especially are often deprived of opportunities

Figure 2. Video-recording writing, written text and objects for learners with limited vision.

Figure 3. Projecting magnified texts, figures, sketches and objects to learners with limited vision.

to study specific aspects because they often cannot visually 'see' or 'perceive' what they are dealing with. Partially-sighted learners as illustrated in Figure 3 have the advantage that text and sketches can be magnified and enlarged to such extent that the smallest detail may be appreciated. Individualisation and teaching principles (Fraser, Loubser and van Rooy, 1996) are emphasised by a direct line of communication between the teacher and the learners. The use of appropriate educational technologies enhances such interaction.

This deprivation causes blind learners to be less competitive during the learning of biology. Blind learners will only be able to be competitive when they are fully exposed to all biology phenomena. Nagel and Stobbs (2003) argued that

"*…benchmarking against the regular curriculum is extremely important because we've got to foot it with this competitive world that we live in. Like it, or not. And if you want a job you have to compete, you have to be there, you have to develop skills and talents. Part of this is having the ability to know and to deal with others, and to live in the real world. You have to learn to take the knocks and have the ability to deal with prejudices.*"

What became evident in the investigation was the good amount of time and effort educators were spending with their learners in the biology and life science classrooms. It appeared as if the pastoral role of the educator as defined by the Norms and Standards for Educators (2000) predominantly exceeded the teaching of biology and life sciences to these learners.

Discussion and educational implications

Many variables restrict effective teaching and learning in the life sciences/biology classroom. Overall, just a small number of blind learners take science-related subjects up to Grade 12. One could attribute this problem to various factors.

Most educators working at schools for the blind and visually impaired received a general education training qualification. They lack ideas to adapt the curriculum to accommodate blind and visually-impaired learners in the life sciences' environment. This implies that they will not encourage learners to do a difficult subject while they cannot mediate or facilitate it properly. Sapon-Shevin (1996) maintains that "… if children who are 'different' in any way are routinely … excluded, this is not a productive learning environment. Wouldn't improvements in classroom climate have a salutary effect on all students?" It is true that many educators do not possess relevant competences to mediate life sciences to blind and visually-impaired learners; hence they do not want to expose their weaknesses. The following examples were taken from the interviews of how educators dealt with the teaching of similarities and differences in the science classroom. One respondent (R1) stated:

"*When you work with blind learners, use concrete things (MS.2) to show them similarities and differences and avoid abstract things like light and darkness, black and white, beautiful and ugly (MS.3).*"

The bracketed codes (MS.2), (MS.3) etc are codes allocated for responses extracted from the transcribed interviews. The coding and categorisation of responses was used to cluster or group responses showing similar trends or characteristics. Using the same code across all respondents' opinions allowed us to extract common phenomena. In qualitative designs it has similar functions as measured frequencies in quantitative descriptions.

It is believed that "[p]ersons with visual impairments have been one of the most difficult populations to accommodate …" (Butler *et al*, 2002, 166). These authors then argued that for the trend to be reduced, it is "… imperative that barriers … be resolved."

Another respondent (R2) stated:

"*Experience has taught me over the years that deep stuff does not work (MS.3) well with blind learners when you talk about similarities and differences. Say, you want to teach them about black and white, refer the colour black to a coal and the colour white to an ice cube (MS.2).*"

Basically, biology concepts indicating similarities and differences are used. For example, during an activity that the researcher observed, which concerned respiration and photosynthesis, the educator indicated similarities and differences there. The respondent (R4) explained as follows:

"*Basically biology concepts (MS.5) indicating similarities and differences are used. For example when one is mediating learning about respiration and photosynthesis, there are similarities and differences there. What one should always bear in mind is to inculcate and introduce to learners ordinary (MS.5) and exceptional features (MS.6) of parts, organisms, processes*, etc."

In addition, educators relied on description and explanation of aspects to blind learners. Another respondent replied:

"*ja, although I don't fully agree with that statement – look the traditional approach was about the teacher giving all the information to the learner and the teacher being the only source of knowledge so we are seldom applying that somewhere some-*

how we do apply that maybe you find that they have got nothing no background they don't have any concept on that subject that you might be delivering but now we are approaching the outcomes-based one that one is where the teacher becomes the facilitator…"

The researchers further discovered that most educators relied on concepts used in everyday life. Examples given above and the following argument bear testimony to this point. One respondent (R6) indicated: "*Concepts (MS.2) such as similarities and differences are used in everyday life (MS.7). What I do, I reinforce it by making use of both concrete (MS.2) and abstract examples (MS.8)*."

Certain advantages of creating opportunities for blind learners to distinguish between similarities and differences were mentioned. If similarities and differences can be observed in a tactile way, learners have immediate access to information. In addition, learners' ability to describe and explain is enhanced.

In the past, special schools used to offer their own curriculum (comprising pre-vocational training, commercial subjects, religious subjects, languages and social sciences subjects). Educators, therefore, found it difficult to offer a curriculum nationally prescribed by the Department of Education (with reference here to South Africa). Blind learners seem to cope better in physiology than other life science subjects. This is so because there are drawings and also good models that the blind can feel tactually. In addition, physiology seems to present fewer problems in terms of adaptations because it comprises more theory than practice.

Braille books, recorded tapes, friends, educators, magazines, internet, experts, the environment, radio and television are preferred methods for accessing information by blind learners and their educators at South African schools.

Regrettably, most schools use outdated and worn-out books without diagrams, relief maps, and other methods of tactilely presenting information. When orders are placed with printing presses, books arrive some months or a year later when they are no longer required. In other instances, printing presses do not produce them because it is not cost-effective to do so due to the small orders placed by schools.

Computers could be a solution, but those who are in charge of them are not computer-literate and they use them for their private matters. When learners borrow books from book lending institutions, the huge demand for such resources only allows learners to keep them for a few months only. When they return them, it means they have no sources to refer to or obtain information. In the past, special schools used to have Braille specialists whose tasks among others included producing Braille books. Such posts have at the present moment been terminated in many South African schools, with the implication that in-house Braille production is no longer done – to the detriment of learners. This implies that without the assistance of sighted people, blind learners cannot benefit from these facilities. Such factors disbar blind and visually-impaired learners from obtaining information in unfamiliar and complex settings.

Figure 4. Construction kits enhance learning by supplying tactile access to size, form and shape.

Since there is a need to provide life science subjects to blind and visually-impaired learners as well as other disadvantaged children, Departments of Education, private foundations, parents, communities, etc, should become partners in educational development by providing personnel, training, equipment, technical assistance, etc. This type of partnership is crucial for eradicating disparities in education because schools for the blind and in particular educators will benefit in many ways, including and not limited to: learning from experts, sharing experiences and exchanging constructive ideas.

Furthermore, partners in educational development will help upgrade services rendered to blind and visually-impaired learners as well as promoting the well-being of the clients they are serving. Sapon-Shevin (1996) argued that teachers whose teaching repertoires are limited to frontal, lecture-style instruction will need to explore more interactive, engaging ways of teaching. The author argued further that educators should "… seek to find new ways to use those talents and skills so that all students can benefit from highly specialised teaching strategies and adaptations." Therefore, it is imperative that professionals working with blind (and visually-impaired) learners should be introduced to new learning mediation approaches e.g. collaborative learning, cooperative teaching, peer tutoring and other innovative scheduling and planning activities, because in the authors' view, that would yield better outcomes in the teaching and learning mediation of life sciences. Figure 4 for example, illustrates a learner using a large model of a flower that can be dismantled and assembled during the mediation process. Models can be adapted to fit the learning conditions and learning outcomes to be achieved.

In order for blind learners to perform better in science-related subjects, the researchers recommend an analysis of learners' needs for a myriad of reasons. This should be done on a regular basis in order to determine learners' strengths and weaknesses based on the learning mediation demands, on all the activities and tasks the learner could do successfully and well. Success always positively enhances a learner's self-image and motivation.

From this, one can therefore continue recommending that education should be delivered in a way that suits and meets blind learners' learning mediation needs. Higgins and Ballard (2000) support this argument by stating that when teachers teach these students with similar expectations to those held for others of their age, and also teach them with recognition and responsiveness to their particular communication and related needs, blind students construct blindness as part of ordinary human experience. Adaptations in certain instances could, as Friend and Bursuck (1999) view them, include bypassing a learner's learning needs by allowing or giving the

learner room to employ compensatory learning mediation strategies, making a modification in classroom learning mediation or organisation, and instructing a learner in basic or independent learning skills. Facilitators or mediators of learning should know and understand that, to blind learners, perception and sensory awareness are requirements for effective biology learning mediation. Erwin *et al* (2001) emphasised that teaching science to students with visual impairments must be firmly grounded in a multi-sensory approach if students are to receive positive benefits, such as activities related to tactile and auditory interactions, and therefore ample opportunity to manipulate equipment and materials must be provided.

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