

Teaching science to visually impaired students: A small-scale qualitative study*

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Abstract: Students have long regarded science as a difficult subject because of hard and abstract concepts. Traditional science teaching has been depended mostly on visual instruction. This makes it difficult for visually impaired (VI) or partially sighted students included in regular classrooms to learn the concepts. Blind students on the other hand, have no visual input at all. They need to learn using other senses such as touching and hearing. Classrooms should be adapted and instruction should be adjusted for better science teaching to VI students. The purpose of this study was to investigate how VI students learn science. The results of the data obtained via interviews and observations revealed that VI students need instructional and environmental accommodations to learn science. They need more tactual and audio experiences than visual instruction. Suggestions and implications about teaching science to students with visual impairments are discussed.

Key words: visually impaired; science teaching; blind

1. Introduction

The areas of science and mathematics have traditionally been inaccessible to students with visual impairments. Fields such as chemistry, physics, engineering, biology, and mathematics are common with visually-presented concepts and information. This visual information has not been made available for widespread use in a format easily accessible to blind and VI students.

Visually impaired students were reported to have the same range of cognitive abilities as sighted students (Kumar, Ramasamy & Stefanich, 2001) and with accommodations can master higher-order science concepts as well as sighted students (Jones, Minogue, Oppewal, Cook & Broadwell, 2006). Stefanich and Norman (1996) in a national survey found that most science teachers and college science educators “have had little or no direct experience in teaching disabled students, they do not expose the students in methods classes to instructional strategies best suited for participation by all students, and often hold stereotypical views of what students with disabilities can and cannot do” (p. 51). A literature search for existing studies on instructional materials and strategies for teaching science to VI students has revealed that there is a severe shortage in this area of study.

2. Problem statement

* An earlier version of this paper was presented at the XIII.IOSTE Symposium, the use of Science and Technology Education for Peace and Sustainable Development, September 21-26, 2008, Kusadasi/Turkey.

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This study is going to investigate how teachers teach science to VI students. VI students are not necessarily learning disabled; they probably just need accommodations and more time to learn the same things as their sighted peer do. If they are given this opportunity, they can learn anything and achieve the same success as their sighted peers do. Since they are a part of society, they have the right to have equal opportunity for education. To provide an equal opportunity of education for VI students, there must be some accommodations in learning environments and in the curriculum materials. To do this, there must be relevant and enough information about teaching strategies, VI students' needs, learning environments, etc. Today, one can find a great deal of research about science education and teaching science to regular and learning disabled (LD) students. VI students are as important as all the other students and people in the community. Therefore, it must be educators' responsibility to investigate every aspect of teaching and learning process for VI students to improve the educational settings they are taught, to improve the instruction for VI students, and to improve the VI students' success in becoming part of an educated society. Although there are studies investigating these issues for VI students, they are not sufficient in number and most of them are outdated.

The terms handicapped and disabled should be identified clearly in order to serve these students better. Heward and Orlansky (1992) defined these terms as follows: A disabled person may have lost a particular body part or organ, or some parts of his/her body may not function in the same way that non-disabled person's body parts function. The term impairment is often used synonymously.

A handicapped person may have problems in interacting with the environment due to his/her disability or impairment. A disabled person is not necessarily handicapped in all environments. A disabled person may be handicapped if the physical disability causes problems. For instance, a person who has lost one of his/her legs or arms may be handicapped in a swimming contest but he/she, using an artificial leg or arm, most probably will have no handicap in a classroom competing against his/her classmates.

Buffer and Scott (1986) described VI students as handicapped by their difficulty or inability to see. The following terms are frequently used for visual impairments: low vision, partially sighted, functionally blind, and blind (near or totally). Partially sighted students have limited vision and can see to some extent with modifications and corrective lenses. Some functionally blind students can move around classroom safely, and others may require accommodations to do so. Near blindness or total blindness are included in the blind category. These students have severely limited vision. They cannot see. They depend entirely on other senses. Most of these students can use Braille to read and write (Cox & Dykes, 2001). The Braille'n Speak, is a portable device which contains a speech synthesizer, a Braille keyboard, serial port for interfacing capabilities, and memory. Text entered on the Braille keyboard can be sent out the port in standard ASCII format. ASCII text coming in through the port can be immediately spoken by the Braille'n Speak. The Braille'n Speak has long been used by blind students and professionals as a note-taking device, and more currently, as a speech synthesizer for a computer.

The purpose of this study is to investigate and gain insight into how teachers teach science to VI students. Teaching and learning enterprise of VI students is a very broad subject. In addition, this study is a small scale research in terms of data collection and its purpose. Therefore, this study will be focusing on science teaching to VI students. Since science is sometimes abstract, it is often difficult to teach, and depends mostly on visual instruction. Challenges VI students may face at schools, special settings and adaptations required in learning environments, and characteristics of VI students were investigated.

3. Theoretical background

Most of the science teachers and college science educators in Stefanich and Norman's (1996) study believed that students with visual impairment could become scientists such as chemists. Indeed, most students who have visual impairments have cognitive abilities equivalent to their peers but there seems to be a large gap between teachers' beliefs about students' capabilities and instructional resources available to help these students realize their full potential. There is evidence that students with disabilities are often not given the same opportunities to experience science as non-disabled students. Special education teachers often lack knowledge about the science curriculum, science content, and science pedagogy (McCarthy, 2005).

Parry, Braizer and Fischbach (1997) reported their experiences with a blind student in a physics class and suggested that even a student blind from birth could deal successfully with a college-level pre-med physics course, if provided with appropriate faculty and student support. They emphasized the necessity for a one-on-one tutorial as the primary mechanism for learning. Including students with disabilities in regular classrooms requires some adjustments in the learning environments and in the instructional techniques. In general, successful classroom teachers have the skills to teach students with disabilities. The instructional units should be designed in such a way that it must emphasize that every student has potential that appear at different levels with different teaching methods. Handicapped students may have difficulties in understanding instructions and thus in responding. A special group among the students with disabilities is the VI or blind students. A visually handicapped student reads and writes in Braille more slowly than sighted students read and write using printed material. As everyone would agree, VI students have the same needs in life science as their sighted peers. However, they lack the ability to observe the environment.

In a college level study, Baughman and Zollman (1977) reported their experiences including a blind student in a physics laboratory. They adopted all of the equipment for use by the blind student by using regular physics instructional materials which included a meter stick, timer, syringes, balance, graph board, and volume cubes. This study indicates that regular laboratory apparatus can be adapted to be used by the visually impaired students.

Learning is effortful and means changing and challenging knowledge. To learn an abstract concept such as those in science requires as much hands-on activity as possible. An upper elementary school teacher describes a lesson plan, which involves students in an experiment about plant growth. The activity was chosen because it provided a concrete experience of the abstract concept of "growth" (De Haaff, 1977). We all know that science experiences depend mostly on visual data and we may not know how hard it can be for a VI student being in a science laboratory. Eichenberger (1974) suggested that since a blind person seriously lack the skills in taking notes and recording data, it is helpful if the blind student can work with a sighted peer in conducting experiments which most of the time require taking data. While the blind student is operating the equipment, the peer student can explain the results and record the data for the blind student. 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. Chemical experiments cause problems since they require visual observations in most cases such as chemical reactions. If bubbles are emitted in a chemical reaction or if a chemical reaction involves a temperature change, the blind student can feel the reaction in progress by hearing or by touching. However, if a color change is involved in the reaction, the blind student will need his/her sighted partner to explain the reaction for him/her.

Wagner (1995) described how to prepare tactile measuring tools for visually impaired students by photocopying sections of a meter scale onto transparencies, and pasting the cut sections into a meter long scale, and using staples or glue to emboss each centimeter marking. The visually impaired student could use this tactile

scale to practice measuring objects. According to Wagner (1995), such measurement activities should help students with visual impairments “gain self-confidence in a skill easily transferable to real life” (p. 77).

4. Methods

This study is qualitative in nature. It is not the intent of this study to find new ways to improve instruction in teaching science to VI students. Instead, the purpose of this study is to investigate, describe, and explore the ways that VI students learn science. It includes both descriptive and exploratory approaches.

Data collection methods were participant observation and audio and video taped semi-structured interviews. Observations were carried out in a state-funded school for the blind in northeast United States. Researcher as a participant observer observed a science class and took notes. Interviews were planned with a science teacher of seven and eight grade VI students, a blind graduate student from the state university in the same city, and a counselor from the Office for Disability Services (ODS) at the state university. However, graduate student cancelled the interview at the time of interview because of his busy final schedule. Researcher managed to interview Mr. Miller who was a 48 year-old VI person. Mrs. Johnson (the name is pseudonym) was a science teacher at the state school for the blind for 12 years. Upon her request she was interviewed in her class after the observation session. Mr. Miller (the name is pseudonym) had a job in a wakeup service. He was very comfortable in using technological devices such as computer, printer, and fax. He was interviewed in his house at his choice of time. Mrs. Lewis (the name is pseudonym) worked as a counselor at the ODS located within the state university. ODS collaborates with instructors and students with documented disabilities to provide reasonable accommodations, auxiliary aids, and support services that are based upon documentation, functional limitations, and a collaborative assessment of needs. Interview with Mrs. Lewis was video taped. Services, which the office provides such as technology lab and print material, were video taped as well as the interview. The observation lasted two hours and the interviews took about an hour each. Observation and interview data were transcribed and analyzed by the researcher.

5. Results

Students in the science class seemed to be very comfortable with walking around in the classroom. They seemed to know the locations of all the desks, chairs, and equipment in the class. They were comfortable with using Braille to take notes during a class discussion. They were using computers very well, like normal sighted students. One surprising thing was that, they could hear really well. During a computer application, they concentrated on what they were doing and were not interrupted by the other sounds. The students had talking computers and they were sitting next to each other. When they type or put something in, it is read to them out loud so that they would know what they were typing. However, when you think of 3-4 such computers placed next to each other and all are talking at the same time that it might become difficult to distinguish and understand what they are saying. Surprisingly, they can discern theirs from others; they tune in on theirs, and others do not distract them.

Therefore, being blind may not necessarily mean that those students are not capable of doing certain activities in regular classroom settings. However, as pointed out by the science teacher, they may need more time to cover the same topics as in a regular school. Since all students including VI students have to pass the proficiency tests, they also have to cover the same topics necessitated by the state curriculum. The science

teachers of the VI students indicated this point in the interview:

Mrs. Johnson: I teach the same things you would learn in a public school but may be at a slower pace, what they cover in one year; it might take me two years to get through.... I am still geared towards the proficiency tests, because, that's a thing they have to pass just as the same as anybody else...but, I would say that one thing it sets apart is that they definitely need things at a slower pace, they can not read as fast as a normal sighted kid, their reading level tends to be lower and its much slower...

Since science instruction heavily depends on visual instruction, VI students may have difficulty in constructing abstract concepts because of the lack of visual input. They need mostly tactual and more hands on experiences to learn science. To have an understanding of an object VI student needs to touch and feel it and this can take longer for VI students than it is for sighted students. The science classroom where the observation took place was adapted for VI students. There were a lot of things (stuffed animal figures, rocks, embossed maps, etc.) that students could touch and learn science by feeling; they "read" these materials by the sense of touch. In addition, they may need mostly audio input and teachers have important responsibility in providing these needs. Teaching VI students resembles teaching learning-disabled students in that both takes more time than one would spend in a regular classroom. Some of the blind students may be learning disabled (LD), and/or developmentally handicapped, as well as being VI.

Mrs. Johnson: They need as much hands-on as you can get because, they can't form the same concepts that we can form because we can see visually and they cannot... So you are not going to be able to show them a diagram and they are not going to be able to understand it. You might have to try to present it tactually, if you can or break it down into parts, it is a lot like teaching LD (learning disabled) kids.

VI students can carry out experiments and assume the roles of members in a group work just as one would use in any regular classroom. Only difference will be that they will need guidance, and/or a sighted peer to work with them in case they need help.

Mrs. Johnson: When we actually set up the experiment it really won't be any differently, they can measure, we were going to put a tea spoon of each thing and with the sugar water they can measure that out, they can use the eye dropper to put in twenty drops of sugar water in task tubes. But of course, I have to kind of be there, sometimes a kid might not be able to use an eye dropper or he might not be able to know that the eye dropper is full or not.

They work as a team very well, not different from sighted students. Collaborative learning may work well with VI students. A sighted student can be included in a group so that he can tell his friends if there is anything involved in the experiment that they will not comprehend by tactual learning and visual input is necessary.

Mrs. Johnson: We do a lot of teamwork; one student will be recorder, I might have a student that cannot see teamed up with two students that can see. For instance if we were doing like a task with acids and bases, if we were doing litmus paper, the students that can see can read the litmus paper and say, yes there has been a color change and what that color change is, for the students that can't see. So, we do a lot of collaborative learning.

According to interview results, it was found that VI students were generally poor spellers and slower readers and hence they needed more time to read or to write something down. They could not read long passages; they would be tired. They tended not to explore their environment. They would rather prefer others do something for them than to go and get it by themselves. They may not sometimes accommodate into regular school classrooms. Since things move very quickly in regular schools, they cannot keep up with their sighted peers and they end up coming to a school for the blind. Some of their senses may be stronger than normal students. They may hear better

than their sighted peers and feel the details of raised graphs by touching.

Mrs. Johnson: I don't know if their hearings are any better or they are just more tuned in... but you can be having a whispering conversation with the student and the rest of them are hearing it... they can hear in my room there is these fluorescent lights up there. That will actually make high pitch buzz noise, I don't even hear, but they do... They have these devices that speak, everything they put in, everything they type in, is read to them as they typing it in. They can discern theirs from everybody else's in the room; I mean it's just amazing to me. They can, they just tuned in on theirs, and the other ones do not distract them, which I think is different.

Students with usual impairments may have difficulties in understanding the subject due to traditional classroom instruction techniques. They can hear lectures but they may not have access to textbooks, classroom presentations, overhead projector transparencies, library materials, and chalkboard. Unfortunately, visual learning is a large part of traditional instruction settings. Some VI students use Braille, but some have no knowledge of Braille. Most of them use adopted technology such as a computer, closed circuit TV (CCTV), enlargements, tapes, and image enhanced materials. A counselor interviewed in this study worked in an office which produces classroom materials for VI students. The office provides appropriate academic services and accommodations for all disabled students in case of request of their services.

Mrs. Lewis: Our office, The Office for Disability Services (ODS), is responsible for providing alternative media services, assistive technology services, counseling services, adaptive transportation, exam accommodations, interpreting and transcribing, learning disability testing, and note taking assistance.

Several studies have investigated the problems of visually impaired people in performing activities of daily life (Bikson & Bikson, 1981; Center for the Partially Sighted, 1980). Everyday circumstances and tasks that are taken for granted by sighted people could significantly disable visually impaired people. One of the interviewees in this study raised one such difficulty:

Mr. Miller: I work in a wake up service. I wake up at around 5:00 am in the morning and call people who wanted to be awoken. Then I usually go for a walk... One thing I want to say is that dollar bills are difficult to differentiate. A distinguishable mark or emboss on money would be very helpful for me.

Genensky, et al (1979) labeled these problems as the visual environmental adaptation problems (VEAPs) of partially sighted people and defined them, as "any problems this population may have in carrying out activities that have a large visual component" (p. 1), and that are important in the educational, vocational, and social adaptation of partially sighted people in a fully sighted society (Kalloniatis & Johnston, 1994).

6. Discussion and conclusion

There should be instructional and environmental accommodations according to the needs of VI students. VI students may need preferential seating because they mostly listen to the instructor. Laboratory equipment should be made accessible to blind students to help them build self-esteem and independence. Any adaptations made must account for safety and proactively prevent any possible dangerous situations from arising. A sighted laboratory assistant could take the readings and measurements and act as the blind student's "eyes" and "arms" for some of the work such as mixing chemicals, heating solutions, etc. They may also need exam accommodations, which may include adopted technology. Teachers may help VI students by providing an orientation about the physical layout of the classroom with locations of things like low-hanging objects in the classroom. Teachers should avoid using terms such as "look at this" while they are pointing to something on the board. They should

rather speak aloud about what is written on the board. It is important for VI students to have access to class materials like the other students in the classroom. In order to do that, they may need print materials in alternative formats such as materials converted to audiotapes, scanned onto disks, enlarged or imaged enhanced, and Braille. It is the teachers' responsibility to have these alternative materials available prior to the beginning of the classes. Since most VI students are dependent learners, they may need a lab assistant or lab partner in courses that have a lab section. Students with visual impairments use tactile and kinesthetic input to learn about their environments. Any visual materials used in classrooms need to be adapted for use by students who do not have the visual skills required for the task. Charts, models, maps, and graphs will have greater educational value for students with visual impairments if they can be "read" using the sense of touch. Auditory input provides another way students can gain information. Teachers should not assume, however, that students will understand verbal input in the same way and at the same depth as sighted students understand visual input. Most students with visual impairments have some usable vision. Their visual learning can become more efficient if they can enhance their skill to use their vision through training or the use of assistive devices. An extra light source at the student's work area can be helpful for some students (Heward, 2000). The student's position in the classroom in relation to visual presentations should allow for a direct view. Information written on the chalkboard should be large. All visual aids should have clear, sharp images.

The academic curriculum appropriate for students with visual impairments is determined by their cognitive abilities. The goals and objectives set for students without visual impairments do not need to be changed for a VI student, but different methods may be used for accomplishing the goals. Many students with visual impairments, however, require instruction in additional curricular areas. Teachers and schools frequently need to emphasize orientation and mobility training, daily living skills, and social skills for students with visual impairments. Traditional ways can be used for assessment. Questioning and literature review help teachers to recognize whether VI students actually understood what is taught or not.

In addition to these, there are guide dogs helping VI students and VI people in their daily living. They should be allowed to anywhere with VI students since they are working animals. They help VI students to find their ways. However, some VI people may not want a guide dog because they may not be able to feed them, or these dogs may not be allowed in the apartments they live.

7. Implications

Due to its nature, the results of this study are not strong enough to make general implications and inferences. However, it still provides some insight into how VI students study and learn. Based on the results of this small-scale study, it may be suggested that VI students should continue to be a part of science education system and they should be provided whatever necessary to help them become scientists. It is hoped that the experiences described in this paper will provide an impetus for science teachers of VI students to become better teachers and for blind students to begin to explore the realms of science that have been so difficult to learn for so long and realize that one does not need to be sighted to be a scientist.

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(Edited by Max and Nydia)