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Mainstreaming Students with Visual Impairment in Secondary Science Education (IX-X): Curriculum Consideration and Assistive Technologies

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Abstract: *As students with visual impairment lack in sight, they are facing a lot of study problems mainly in mainstream secondary schools of Bangladesh, mostly in science subjects. Science is full of visual cues and instructions which is difficult to learn by students with visual impairment. The article found that it is not possible to do some academic activities for students with visual impairment without curriculum consideration and assistive technologies, especially in science related subjects. The paper attempts to describe the current situation of science education in secondary schools (IX-X) and find out the problems they are facing in the mainstream schools of Bangladesh. Interview with science teachers and students with visual impairment of class IX-X were done, science classes were observed and many secondary sources of information were analyzed. Finally the paper explains the curriculum consideration procedure for students with visual impairment and recommends effective teaching techniques and assistive technologies for them, which will help to study science.*

Keywords: *Mainstreaming, Visual Impairment, Science education, Assistive technology.*

Over the last few decades the world has produced a number of declarations and agreements to provide an inclusive society for all as an output of inclusive education. Among those declarations the UNESCO Declaration on Education For All (1990), the Salamanca Declaration on Inclusive Education (1994), the Dakar Framework (2000) and Convention of the Rights of the Persons with disabilities- CRPD, (2006)

strongly and clearly represent the rights of education of children with special needs. These international initiatives have moved the education systems of different countries towards inclusive education (Forlin and Forlin, 1998). Like many developed and developing countries, Bangladesh is a signatory country to these international declarations (Directorate of Primary Education [DPE] and Centre for Services and Information on Disability [CSID], 2002). Bangladesh is a small developing nation of Asia bordered by India and Myanmar. Poverty and illiteracy are common phenomena for this country. The present population of the country is about 166280,712 (Index Mundi**,** 2014) and 15% of this population has a disability (World Health Organization & World Bank, 2011). Some 89% of the people with disabilities are not in education (Directorate of Primary Education & Centre for Services and Information on Disability, 2002). But, the constitution of Bangladesh, Education policy- 2010, Persons with Disabilities' Rights and the Protection Act, 2013 clearly spelled out special needs children's right to education in mainstream schools. To ensure their access to secondary science education (IX-X) the curriculum and various teachers training programs provided by the Ministry of Education (MoE) is not sufficient as inclusive education demands a package of different types of teaching skills, effective curriculum and assistive technologies. In a regular class teacher can continue writing in the board without speaking. But, if there is a students with visual impairment in the class, teacher needs to speak while writing in the board and give proper oral guidelines so that the students with visual impairment understand the discussed topic. As science education is full visual information it seems more difficult for students with visual impairment. But, literature suggests that with the help of assistive technologies they can study science. Teaching strategies also need some modification and the curriculum also needs to consider for them (Penny and Mary, 2001).

The aim of this article is to find out the real picture of secondary school (IX-X) science education of students with visual impairment in Bangladesh. It also focuses on finding effective teaching techniques for them and to identify assistive technologies for science education. It also describes the curriculum consideration process for them at secondary schools. It will help them to integrate into mainstream science education at secondary grade (IX-X).

Definition of Terms

Definitions of some terms used in the article are given below.

Visual Impairment

Generally people who can't see are considered as person with Visual Impairment (VI). Defining visual impairment is a contested as well as complex issue. However for the article, the researchers considered both low vision and total blindness as visual impairment. For that reason people with irretrievable sight loss are called visually impaired. Blindness refers to a condition where a person suffers from any of the conditions: total absence of sight; or visual acuity not exceeding 6/60 or 20/200 (Snellen) in the better eye even with correction lenses; or limitation of the field of vision subtending an angle of 20 degree or worse (Jonas and Mosby, 2005). Low vision refers to one who has an impairment of visual functioning even after treatment, and/ or standard refractive correction, and has a visual acuity of less than 6/18 to light perception or a visual field of less than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task (World Health Organization, 1993).

Mainstreaming

Mainstreaming means educating children alongside their non-handicapped peers in the mainstream schools. It is the application of normalization to the education system (Williams, 1999: 254).

Science education

In the article science education means science and mathematics related subjects of class IX-X in secondary education i.e. Mathematics, General science, Physics, Chemistry, Biology and Higher Mathematics.

Curriculum and curriculum consideration

Curriculum is all the planned experience provided by the school to assist pupils in attaining the designated learning outcomes to the best of their abilities (Evens, 1942; cited in Kader, 1999). General curriculum need to be made flexible for students with Special Educational Needs (SEN) in some context. This type of curriculum flexibility is named curriculum consideration in the article. Curriculum, in the article, means science and mathematics curriculum of class IX-X.

Assistive technologies

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 is called assistive technology (IDEA, 2004). Equipment, products or devices which help to make science understandable for the students with visually impairment is treated as Assistive technologies in the article.

Methodology

Seven Secondary schools of Bangladesh were purposively selected from Dhaka and Rajshahi division. Among the 7 schools 3 schools are from rural areas and another 4 schools from urban areas. 10 Science teachers were also selected from these schools purposively. Among the 10 teachers 3 were mathematics teachers and 7 were teachers of other science subjects. At the time of teacher selection some criteria were considered like male-female, year of experience and type of school. Another type of respondent was students with visual impairment. 12 students with visual impairment were selected from two divisions. Snow ball sampling technique was followed to select them. Availability and gender of the student were considered at the time of student selection. Among these 12 students 5 were from class IX and 7 were from class X. Two different semi-structured interview schedules were administered to collect information from secondary school science teachers and students with visual impairment. The interview schedule for teachers have items related to present situation and future possibilities of science education of students with visual impairment. Interview schedule for students with visual impairment consisted items on opportunity to study science, problems they are facing and their expectations regarding science education. Classroom observation was also done. 5 classes from 7 schools were observed and an observation checklist was administered. Findings from the interview schedules and observation help to get the real picture of science education of students with visual impairment (IX-X) in Bangladesh. Then the extract of the findings blend with the literature to find out effective teaching strategies of students with visual impairment so that they can integrate into the mainstream science education. Besides, secondary data was also analyzed to find out the assistive technologies for students with visual impairment. Finally, a thick description of the curriculum consideration process for students with visual impairment was delivered. All ethical issues were strictly followed in all steps of the research.

Data analysis and Findings

Science education is very difficult for students with visual impairment as education system of Bangladesh provides a little in this perspective. Because in an inclusive setting, teachers need more than ever before to understand students with diverse exceptionalities, their characteristics, their needs, and effective strategies to work with them (Friend and Bursuck, 1999; cited in Kumar and Stefanich, 2001). Below the findings are discussed thematically:

Present situation of Science education of students with visual impairment

It is found that no students with visual impairment study in science group in class IX-X in Bangladesh. All students with visual impairment study arts and humanities

except 1/2 who reads in business group. General science and general mathematics are included in arts and humanities; so students with visual impairment read these two subjects where they face problems in many topics. Students with visual impairment do not learn some topics and another some topics- they only memorize without understanding. In the examination also, they fail to answer of some visual topics like executor and drawing. All of the interviewed students with visual impairment informed they give exam in less than 90% marks but evaluated in 100% marking scale.

Table 1: The main characteristics of the observed classrooms:

Items	**Characteristics**	**Frequency**
Classroom decoration	Well decorated	7
	Not decorated	3
Seating arrangement	U shape	-
	V shape	-
	Circle	-
	Rectangle	-
	Column	7
	Others	-
Teacher-student ratio	≥ 1:40	1
	≥ 1:50	2
	≥ 1:60	2
	≥ 1:70	2
Teacher –student interaction	Friendly	5
	Not friendly	2
Teaching method	Lecture method	7
	Participatory method	-
	Discussion method	-
	Problem solving method	-
	Individual and group work	-
	Others	-
Lesson Plan	Yes	-
	No	7
Teaching aids	Pictorial	-
	Real object	-
	Both real object and pictorial	-
	Tactile aid and Auditory aid	-
	None	7

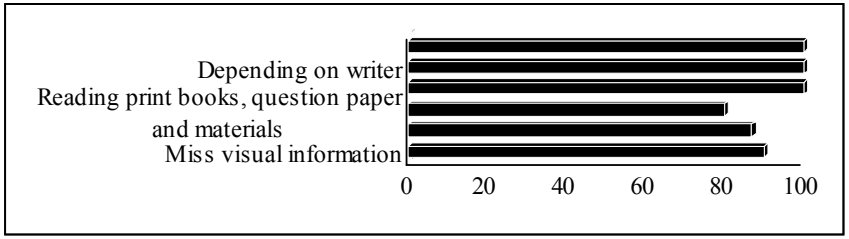
80% interviewed teachers said there is no scope and opportunities to take extra care for students with visual impairment. Their opinion was that it will harmful for both students with and without visual impairment, if teacher tries to give extra time and attention towards students with visual impairment. No assistive device and aid is

found to use in the observed secondary schools, braille books are not available in the library. So, teachers and students with visual impairment think science is very difficult for them.

Problems faced by the students with visual impairment in mainstream schools

Students with visual impairment face a lot of problems for limited vision. 90% interviewed students with visual impairment informed; they miss huge information for sight lacking. One of the students with visual impairment said, “May be a teacher wrote a new spelling in the board, I miss to learn the spelling as I can’t see.” Moreover, students fail to learn many lessons as they can’t write down class lecture. Besides, students with visual impairment are unable to read print materials, which is another reason for information missing. Exam questionnaire is printed which is also inaccessible format for the students with visual impairment. S/he needs to take help from her/his sighted guide to read the question paper. 80% respondents complained these factors make their results down. Besides, students with visual impairment also left behind in some topics for their visual drawback. Such as, they can’t make out many parts of geometry. Simply all of them avoid the topic or memorize it without understanding. 95% students with visual impairment informed they prefer reading arts and humanities as they find science very difficult for them. There in arts also, they have to read General Science and General Mathematics which also contain many visual topics. The only thing they do is simply avoiding the topics. They don’t learn these topics; even don’t give answers of those questions in the answer script of exams. On an average, they give 60-70% answers of the exam but measured in a 100% numbering scale which causes unexpected poor numbers.

Following graph shows the main problems of students with visual impairment in classroom. Percentage have been calculated by students opinion.



Graph 1: Main problems faced by students with visual impairment in classroom

Teacher's thought about science education for students with visual impairment

50% teachers of mainstream schools argued that it is not possible and necessary also to teach everything to students with visual impairment. They said, "They will never be able to draw and explain executor; higher order theorem, trigonometry and other measurements are not also possible for them". 90% interviewed teachers believe there is no way to teach these topics for students with visual impairment. Many other parts of mathematics like logarithm and index, complex algebra, complex equation, charts and graphs are also very difficult for them to learn.

Again, many topics of Physics, Chemistry and Biology are also impossible to learn by the students with visual impairment, informed all the interviewed teachers. 85% science teachers argued, "Students with visual impairment are not able to perform practical laboratory works like frog and worm dissection, dissection of Hibiscus flowers, identifying chemicals, testing many chemical reactions etc. They are also unable to understand and draw different parts of human body i.e. cell, mitochondria, nucleus etc., plant and other animal body parts and actions. So, it is not possible for the students with visual impairment to read science." Another 20% respondent teachers said if the Government of Bangladesh takes necessary and effective measures then students with visual impairment can study in science group. To implement this huge economic support, aids and materials, teachers training and consciousness rising is obligatory.

Recommendation

This picture of science education for students with visual impairment instructs to think on this issue. Literatures from developed countries (Dyson, 2001) show that curriculum consideration is mandatory in these areas; also assistive technologies help students with visual impairment to learn science and mathematics.

The curriculum designed for ordinary children is generally appropriate is generally appropriate for visually impaired children. However, some adaptations to the learning materials and teaching approaches have to be made so that the learning needs of visually impaired children can be met. The curriculum should adopt a consistent, realistic and flexible approach in curriculum planning and implementation. (Educational Bureau of Hongkong, 2013)

Curriculum Consideration

In spite of bringing change in teaching technique, all the topics are not easy for the students with visual impairment to do for sight lacking- like geometry, executor and theorem, drawing charts-graphs and figures, picture drawing and scientific

laboratory. Some are difficult to do like complex equation, trigonometry, measurements etc. The current practice of Bangladesh is that students with visual impairment simply avoid these topics and don't answer questions on these topics as well. Curriculum consideration for them is a way to overcome these types of challenges. It means making topics accessible for students with visual impairment so that they can answer them.

When considering curriculum, first of all a teacher will divide the syllabus of specific subject into three categories, i.e. 'Must do', 'Should do' and 'Could do'. This category will be done depending on the importance of a topic considering the learning outcomes. Again, dividing topics remember the type and severity of vision problem of a student. Teachers first teach them the topics included in 'Must do' category which is mandatory to attain the learning outcomes of that grade. When students with visual impairment successfully learn 'Must do' areas then they will start to learn 'Should do' topics. Students will not start to learn 'should do' category before completing 'Must do' ones. If a student get success in must and should do topics only then s/he will learn 'Could do' topics.

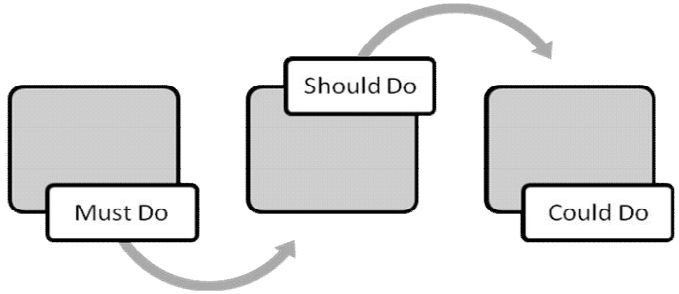


Figure 1: Category of topics according to learning outcome

Moreover, there are also some challenges for students with visual impairment. Suppose, there is a topic in the 'Must do' category which is not possible to solve by a student with visual impairment; then what will be the activity of the teacher? Here comes the strategy of bringing some technical changes in the topic. For example, Teacher can simplify the topic, if simplify isn't enough then s/he can modify that. Still the student cannot learn, and then it may be changed or altered by another similar topic. If all the techniques fail finally the topic can be omitted (Dyson, A., 2001). Here an example of the curriculum consideration procedure is explained:

Say, there is a picture of mitochondria in the question paper; students are asked to identify the organ and describe its function. Students with visual impairment will be

stuck in the first part of the question, identifying the organ. Teacher can simplify it for the students. Like- 'Describe the functions of mitochondria.' This is called simplification.

If there is specific learning outcome about identifying the organ and the question bears some marks in the identification part of the question, teacher can modify the question without visual clues for a student with visual impairment. The question may be-

'Which organ is called the power house of body? Describe the functions of the organ.'

This is the way how a question can be modified for students with visual impairment. Give an alternate is another major area of concentration. In reality, it is impossible for a visual impaired student to do executor, how will the student answer this question? Executor has a specific learning outcome; the teacher can alter it by giving another question for the students with visual impairment keeping the same learning objective. Executor helps to increase analytical ability of a student. But, students with visual impairment are not able to do this. So, another question on analytical ability can be set to measure these skills. If simplification, modification and changing do not work then the topic can be omitted.

Teaching Consideration

As stated in Penny and Mary (2001: 73): "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 student due solely to a vision problem, though the methods for accomplishing the goals may be different".

That means if a teacher brings some changes in the teaching technique, students with visual impairment can continue reading in an inclusive setting. Another study showed students with visual impairment need first-hand experience in learning Mathematics because they lack visual stimulation related to the development of mathematical concepts such as size, shape, color etc. The teacher needs to adapt the learning materials and give examples to the children's level of understanding. (Educational Bureau of Hongkong, 2013) Mainstream schools translate textbooks and syllabus into Braille and adaptive electronic media so that students with visual impairment can get the benefit. The article suggests some teaching considerations based on classroom observation and interview blending with related literature for the students with visual impairment in a mainstream class. Teachers of an inclusive class should:

Allow lectures to be audio recorded.

- Encourage direct conversation and speak directly to the students with visual impairment in a normal tone.
- Always give specific instructions, like - please take the centimeter ruler and measure the length of the table.
- Provide large print copies of written materials for students with low vision. Try to increase visual contrast of written materials.
- Provide a wide range of direct learning experiences. Use real objects so that the student can feel them by touch.
- Allow students to explore in their natural environment, like- plants, animals, and instruments etc.
- Supply students with tactile diagrams and graphs labeled by braille.
- Use Braille labels on chemicals and reagent containers.
- Keep the laboratory aisles cleared, and do not leave doors half-open.
- Instruct other students in class to yield the right of way for the student with visual impairment whether or not that student is using long canes.
- If possible, provide a laboratory assistant or find a volunteer in class who is willing to work with the student with visual impairment to read directions and procedures, and guide him/her.
- Provide assistive technologies whenever possible like talking thermometers, voltmeters, timers and calculators, glassware with embossed numbers, sandpaper labeling for poisonous chemicals, and computers with voice or Braille output. Light probes and special adapters, which transform visual and digital signals into audio outputs are also suitable for assisting the visually impaired student in science laboratory settings (AAAS (1991) as cited in Kumar and Stefanich, 2001).
- Whenever teachers use manipulative, models, or other equipment, students with visual impairment need the opportunity to use their tactile and kinesthetic senses to become familiar with the objects to benefit from their use in lessons. Teachers should introduce students with visual impairments to materials and equipment used in the same way and at the same depth as other students understand visual input (Kumar and Stefanich, 2001).

Assistive technologies

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. Tactile and kinesthetic input can provide students

with information about objects they come in contact with and use. (Penny and Mary, 2001)

Klatzy and Lederman (1988), cited by Penny and Mary (2001):

Students with visual impairments use tactile and kinesthetic input to learn about their environments. Such input should not be thought of as 'lesser senses' to use in the absence of vision, but as another system through which learning takes place.

For example, outlining map boundaries with string enables students with visual impairments to use their sense of touch to read maps. Auditory language triggers the creation of mental images that correspond with words. Images are recalled to assist students in comprehending verbal language (Barraga and Erin, 1992; cited in Penny and Mary, 2001). A student with visual impairments is likely to have fewer and less detailed mental images to correspond with verbal language. Such images may differ according to a student's individual experiences and verbal input he or she has received from others (Whitmore and Maker, 1985). General education teachers should observe and interact with students with visual impairments in an effort to determine whether individual students understand verbal input. The teacher must check for comprehension during class discussions and when giving directions. If students are having difficulty understanding what the teacher says, the teacher may need to clarify or expand on their background knowledge or vocabulary. 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. There are many devices which help visual impaired students to learn mathematics; like Taylor Arithmetic frame, Arithmetic and Braille writing scale, Abacus, Talking calculator, Geometric shapes and solids, spur wheel (a serrated wheel revolving in a plated metal handle which is used for making continuous embossed lines on the reverse side of the paper), compass set, Opisometer (a bell rings each time the disc moves a distance of one meter, useful for mapping and understanding mathematical problems in length and perimeter), Primary mathematics kit etc. (Punani and Rawal, 1993). The primary mathematics kit is specially designed for the visually impaired students to comprehend mathematical concepts. It contains a plastic box, slide strips, number boards, fractional strips, braille clock, geometrical shapes, magnetic board and geometric devices.

Moreover, some science aids are also available. Like, conductivity apparatus is an assistive technology for the visual impaired students. It helps to understand the difference in the heat of copper and iron. Another aid is three dimensional raised relief plastic charts. It is a rigid PVC sheet, printed and formed in multi-colors. The

charts make many shapes like plant cell, plant meiosis, plant mitosis, ribonucleic acid, bacterial forms, spirogyra and funaria, depicts fertilization, T.S dicot leaf, human skeleton, circulation system, heart and nervous system, a section of the brain, digestive system, the ear, nose and eye, reproduction organs of male and female etc. (Punani and Rawal, 1993)

There are a number of technical progresses all over the globe that can provide the print disabled and visually impaired people with accessible information systems and study materials which can enable them to equal access of information like the sighted people. ICT brings a radical change in the life of visually impaired all over the world. (Andrea, 2010) Computers with visual impaired friendly software (JAWS, Katha, etc) helps them in educational perspective. Tape-recorder, talking watch and talking mobile are found to be very helpful for them.

Conclusion

The constitution of Bangladesh is clearly spelled out the rights of Visually Impaired people in educational institutions. They have the rights to study with dignity and live independently. Now-a-days, in many countries Visually Impaired students are studying science and doing well in these subjects. But, the picture of Bangladesh is not satisfactory at all. It's time to focus on the issue. Curriculum consideration process should include in the teacher training programs of Bangladesh. Assistive technologies need to make available. But, the most important thing for the visually impaired people is positive thinking and conscious rising. It will smooth the onward ways.

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