SCIENCE TEACHING-LEARNING RESOURCES FOR VISUALLY-IMPAIRED STUDENTS: STEPPING TOWARDS INCLUSION

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Abstract: *Education is a means to bring social changes. It is fundamental right of a learner to access quality education irrespective of subject and learning ability. Traditionally, Science education has not been accessible to visually impaired students. It is injustice to visually impaired learners if they are excluded from basic school science learning on the grounds of their ability. This paper sketches the notion of inclusion in science education at the school level, aimed at bringing visually impaired students into mainstream science education. The major focus is on the issues and concerns of democratizing school science curriculum for visually impaired students. It also encourages prospective science teachers to make science education accessible to visually impaired students using science teaching-learning resources. This could provide good assistance to science teachers in achieving the objectives of inclusive education.*

Keywords: Teaching-learning resource, inclusion, school science

1. INTRODUCTION

Education is a reflection of society. Education should enable students to realize their role in society and how their knowledge and skills could contribute to the community, rather than just transmitting knowledge to the students. This could be the aim of education, which must provide equal and adequate opportunities for all children. Education ought to provide opportunity to learn science despite any learning difficulties and bring them to mainstream of science education. The teacher-centric mechanical approach to teaching could be the reason behind exclusion of learners in learning. Rather, teachers should emphasize an organic or humanistic approach that makes pupils more humanistic with knowledge and helps them understand their citizenry. The fundamental right of children under Article 21A is to obtain quality education. No child left behind to receive primary education, irrespective of caste, creed, or ability. All have to receive an education and inclusive education is stepping towards it. Moreover, various educational policies and Sustainable Development Goals have focused on quality education with inclusion and excellence. Inclusive education is a trademark for achieving the universalization of elementary education.

Despite one or more sensory dysfunctions, students can understand phenomena with sensory organs other than dysfunction. Society naively assumes that students with learning disabilities cannot understand the phenomena comprehensively. When it comes to studying science for visually impaired students, physical education for physically disabled students is observed more specifically. However, there are several examples of significant achievement despite learning difficulties, such as Stephen Hawking. Often, the assumption has been made that visually impaired students (V.I. students) cannot study science efficiently as they have more visualization components in learning. Nevertheless, education cannot neglect students' learning because of their learning difficulties. Education must promote children's interest and adopt new strategies to meet their needs. Science is a

subject that studies living and non-living phenomena, and one must understand the process of the phenomena. In India, the visually impaired can study science to the secondary level. It is difficult to accommodate them in inclusive classrooms. Special schools trained special teachers to teach subjects. Teachers do not have the skills and training to teach science, any other subject, or other students. Schools often ignore them from studying science, but as mentioned in National Curriculum Framework 2005 and the Right to Education Act 2009, one cannot restrict anyone from learning any subject. It also recommends the adoption of alternative strategies and methodologies to fulfil their needs.

1.1. Inclusive Education: International and National Perspectives

Many children are deprived of educational and social inclusion. It is pivotal to provide equal opportunities for learning in education. Inclusive education has emerged as essential issue in education. It has been pointed out by international commitments to provide inclusive education in all countries [24,25,27,29]. 'Inclusive education is the process of addressing students' diverse needs by promoting barrier-free education.' [26]. It is a human rights-based approach towards educating all children, irrespective of their strengths and weaknesses. It is stepping forward to bring marginalized children by dimensions such as poverty, gender, disability, and caste into mainstream education [15,19]. Sustainable Development Goals (2015) and their respective targets also directly address disability (Goal 4: 'Ensure inclusive and quality education for all and promote lifelong learning'; Goal 8: 'Promote inclusive and sustainable economic growth, employment, and decent work for all') [28]. We should confine the concept of inclusive education to a description of the inclusive instructions and needs of Children With Special Needs (CWSN). The best way to understand is to bring them to the mainstream by providing equal and adequate opportunities.

The Developed countries are far ahead of providing equal opportunities to disabled children. However, it is challenging for a country like India to provide equal opportunities due to diversity in language, religion, caste, and so on. Mass education is challenging in India, and providing inclusive education is more challenging as out of the 121 crore populations, about 2.68 crore persons are 'disabled, which is 2.21% of the total population [16]. Despite this, efforts have been made by the Government of India towards the education of children with disabilities to promote inclusive education from the inception of the 'Integrated Education for Disabled Children' (IEDC 1974)[7] to the 'Right to Persons with Disabilities Act' (2016) [20]. It has been accelerated in the Right of Children for Free and Compulsory Education (2009), a scheme of Inclusive Education to achieve the target of Education for All (EFA). A zero rejection policy was adopted under SSA to ensure that Children With Special Needs (CWSN) provided quality education. Rashtriya Madhyamik Shiksha Abhiyan (RMSA) also addressed such issues after the subsume of the Inclusive Education of the Disabled at Secondary Stage (IEDSS) in 2013. There has been initiation in the entire sector, from education to employment. National Council of Educational Research and Training (NCERT) has developed materials on inclusive pedagogy and practices with the key objective of enhancing the skills of regular teachers in handling CWSN in mainstream classrooms. For visually and hearing-impaired students, study materials have been developed in the Digitally Accessible Information System (DAISY) and sign language; both are available on the NIOS website/YouTube [14]. Many schools have infrastructure facilities and learning resources to assist

teachers and disabled students. However, many actions need to be taken in all sectors to overcome the problems faced by disabled children radically.

Education provides equal opportunities to establish a balance in society. Inclusive education is treated as a concept rather than a responsibility. When teachers realize their responsibility and understand children needs, they could provide inclusive education to all. Role of education is not only to bring learners to schools. It should also involve them in classroom processes.

1.2. Status of Disabled Person With Special Reference to Visually Impaired Students in India:

Visual Disability is described as being handicapped by difficulty or inability to see. "Blindness is categorised as: 1) cannot see at all; 2) has no perception of light even with the help of spectacles; 3) has the perception of light but has blurred vision even after using phenomena, contact lenses, etc.; 4) can see the light but cannot see correctly to move about independently; 5) has blurred vision, but her/his eyesight would improve after taking corrective measures; 6) one eye person not to be considered as disabled in seeing" under Section 2(b), Persons with Disabilities Equal Opportunities, Protection of Rights and Full Participation Act, 1995 [18]. Visual disabilities pose more significant challenges than other types of disabilities. There are many visually impaired persons in India, with higher levels of disability after motor disability [4]. As per the Census 2011, out of the population of disabled persons, 19 percentages have a visual disability after 20 and 19 percentages of motor disability and hearing disability, respectively. This could be the same among 0-19 years. Moreover, 30 percentages of children (0-6 years) have visual disabilities [16, 19]. The RTE Act-2009, amended in 2012, provides a promising platform for the inclusion of children with disabilities and further strengthens the Right to Persons with Disabilities Act 2016 [21], which fosters initiatives in education. Few efforts have been made in India, such as the modernization of 10 existing and establishment of 15 new Braille presses to augment their production of Braille presses [20].

Teachers should appreciate the initiatives taken at the national and international levels and realize their role in achieving goals. Teachers should also take the initiative to bring equity and equality in education. All stakeholders come together to enable inclusive education. As responsible citizens of the country, teachers must accept challenges and develop strategies for upliftment in society. Mathews [2] presented a case about the struggle and achievement of a visually impaired child who desired to pursue a science career after X class despite ignorance from teachers, the school principal, and the government. Issues like teachers' lack of motivation, unavailability of resources, and skills to tackle inclusive classroom challenges are prominent in Indian classrooms [19]. A student-friendly classroom environment, social skills, personal principles, and the comfort level of students and teachers laid the foundation for inclusive classrooms [8].

All stakeholders addressing problems externally, rather than focusing on them, should be from within. It is necessary to show the positive intentions of schools and the government. Studies have suggested learning new techniques from one another, showing willingness to change, and adopting new strategies to cater to students' diverse needs to maximize their potential.

1.3. Inclusive Science Education:

Traditionally, sciences have been inaccessible to V.I. students. The nature of Chemistry, Physics and Biology has less space for them. Researchers have

conducted studies on science accessibility for them. They can also be accommodated by sighted students in science learning. They also suggested that they perform practicality and explore science with teachers' efforts and skills to accommodate visually impaired student [6, 12, 13]. The objective of science teaching is to develop scientific literacy. It can also develop scientific curiosity, scientific attitudes, and scientific value among learners. Science teachers should understand students' needs in the classroom without discrimination.

Furthermore, the students understood the scientific process and related it to their daily life. Science is connected to all human activities, despite any sensory dysfunction. Science teaching does not merely transform from one brain to another; it also generates scientific curiosity and the application of knowledge in daily life. No child could be left behind to study science or any other subjects. Inclusion in the science classroom is not as promising as the teacher does not know many strategies to cater to their needs [1,2]. Maguvhe [12] found that teachers lacked practical knowledge and opportunities for then in science. Researchers have also highlighted that if one wants to pursue an interest in science or any other subject, then they thrive on their ambitions and initiatives. Lack of training and accessibility of learning resources could be the reasons for the negligence of inclusive science learning. Nowadays, teaching science is somewhat mechanical, where teachers come to class and transmit the information cited in textbooks. Understanding disabled or visually impaired students' psychology is far behind, as they cannot understand the other students in the classroom. Modification in teaching and assessment practices might serve this purpose, as they are more rigid and unfavorable in the Indian context.

1.4. Scope of accessibility of learning resources in Science:

Researchers have been working in this area, particularly in the field of science. Martin Kunz was a pioneer in tactile illustrations. He developed tactile learning images for blind students during the late 19th century, which are relevant for visually impaired students even in the present context [11]. Fraser and Maguvhe [30] illustrated how to use a combination of three-dimensional models to capture the meaning of two-dimensional drawings (such as the structure of a cell). Wagner [3] described how to prepare tactile measurement tools for V.I. students. Teachers and students can qualitatively identify certain non-hazardous materials using the sense of smell. They can identify chemical reactions involving colors using a colorimeter interfaced with a computer programmed to convert color signals into Braille outputs. Teachers can also use light probes interfaced with Braille computers as detectors for determining endpoints in volumetric analyses. Similarly, modified ultraviolet and infrared spectrophotometers can be used for chemical characterization. There are modifying chromosome kits with "pop-it beads" using readily available tactile markers for teaching cell division [6].

Teachers can perform an activity that enables students with visual impairments to observe a living organism through a sense of touch. Most V.I. students can use braille to read and write. They can use a Braille 'n Speak, Braille keyboard, serial port for interfacing capabilities, and memory. There are resources such as scientific calculators, braille ruler, analog clock, braille or large print yardstick, and braille meterstick available to make the measurement, probability, and data collection activities accessible to the blind students [10]. Teachers can also use real objects and materials to more comprehensively explain and experience. The translation of course syllabi and materials into Braille, adaptive electronic media,

lectures to be audiotaped and written materials for students with partial visual impairments with increased visual contrast and visibility [6]. Thus, teachers can accommodate V.I. students in both science classrooms and laboratories. Researchers have also recommended that direct dialogue with students allows them to explore their natural environments and use real objects. Teachers can use tactile diagrams and graphs outlining liquid glue. Teachers should orient them while working in the laboratory by familiarizing them with emergency exits, chemicals, glassware, equipment, extinguishers, eye sprays, and so on. Teachers can also use Braille labels on chemicals, reagent containers, and instruments. Teachers should play a proactive role and motivate students in the classroom to volunteer in partnering with V.I. students.

Teachers should focus on pedagogical innovations to establish inclusion in the classroom. The teaching-learning process could help realize what students want to learn rather than what the teacher wants to teach. Science teaching is also meaningful in understanding students' needs and making favorable changes in teaching strategies.

2. RESEARCH METHODOLOGY

With the realization of the needs of V.I. students, the researcher intended to explore the accessibility of science. A qualitative research was conducted. The purpose was to investigate, describe, and explore ways in which they learn science.

2.1. Population and Sample:

The population and sample consisted of 35 student-teachers of B.Ed. programme of the academic year 2017-2019 in the Department of Education, University of Delhi, including 23 science pedagogy student-teachers and 12 V.I. student teachers. The researcher adopted the sequential sampling was used to conduct the study. Both descriptive and exploratory approaches were used.

2.2. Tools and Techniques:

Data collection methods included participant observation and semi-structured interviews. The researcher, as a participatory observer observed 23science pedagogy student-teachers. The interview of visually impaired students was carried to collect data from them and their help to develop learning resources

2.3. Data Analysis:

The data were collected using participatory observation during the development of inclusive models by the student-teachers and interview with V.I. student-teachers regarding experience of learning sciences at school level. The interviews were conducted and analyzed using a theme-wise content analysis.

3. DATA ANALYSIS AND INTERPRETATION

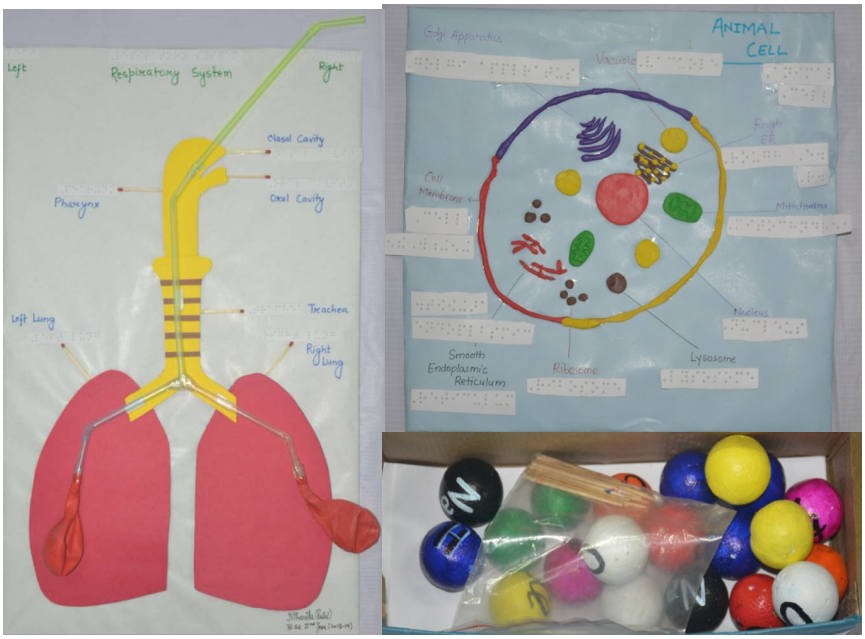
3.1. Identifications of the Problems faced by visually impaired students:

The researcher and student-teachers identified problems of visually impaired students. They have a significant problem with the visualization of scientific concepts, as they have difficulties in seeing things. They also highlighted the issues of flaccid efforts from the perspective of teachers to teach science. They also highlighted Braille books' unavailability, learning resources, instruments, and equipment. All students studied Science until XIII, as prescribed by the central and state governments. The authorities, teachers, and even parents somehow neglect the study of science subjects, resulting in the demarcation from science and told them to opt for music as an alternative to science subjects. They also said

that there are unavailability of science teachers, and unfavourable attitude towards their learning. In contrast, they provided positive attitude of teachers for inclusive science teaching by citing science teachers' efforts to provide resources and use them in teaching-learning processes. They also suggested that they can study science subjects until class XII. Therefore, it is desirable to teach science subjects from their early age. So, they can connect the scientific concept using previous knowledge. They also expressed their views on inclusive education; they felt that inclusive education has brought so many changes in recent days. It also addresses issues such as a lack of resource facilities for them. Policies seem good on paper and are not significant at ground level, especially for visually impaired students. This research suggests that practical inclusion in real classroom is foremost alongside initiation on paper. The prime focus should be on providing infrastructure facilities and resources. The governments have provided learning resources to some extent. But still far behind in rural areas.

3.2. Development of learning resources:

After identifying the problems of visually impaired students, the student-teachers developed learning resources. Learning resources were developed for topics such as dispersion of light, water cycle, chemical bonds, circulatory system, animal cell, magnetic, electric circuit, leaf venation, plant cell, wind energy, binary fission, human executive system, human digestive system, human respiratory system, neuron structure, life cycle of butterfly, structure of DNA, Mendel's law, human hand, structure of flower, photosynthesis, structure of eye, and cell type.



Picture 1: Some Developed Inclusive Learning Resources

3.3. Data Analysis of Inclusive Learning Resource:

The scientific topics selected by student-teachers were appropriate and relevant. They had a good understanding of the concept and executed content knowledge in learning resources. The learning resources they developed were comprehensive, and as per the topic, the majority of resources have implications from primary to secondary, and some of them are for higher secondary. Also, they also well taken into account the needs of V.I. students.

They have selected various alternative models to teach science viz.3-D models, working models, multimedia, and science experimentation etc. Some of them also developed experiments to demonstrate scientific concepts that are easy to understand, perform, touch, and perform, even for visually impaired students. They used the material appropriately and given the 3D effect to increase the usability of visually impaired students. Multimedia of the science concept has also been developed by students to assist V.I. students in learning as per the students' level and comprehension.

Students used harmless, non-hazardous materials to develop charts and models and demonstrated experiments such as clay, colors, papers, sticks, threads, cotton, cereals, pulses, and glue to develop learning resources. Thus, visually, students can touch and visualize concepts. The majority of students labelled learning resources with the Braille text as well. Thus, visually impaired students can touch and come to know the names of experiments, models, concepts, organelles, and parts. Most students take care of the cost of resources. All resources are cost effective. V.I. students can use these resources for self-learning. They also observed learning resources and found them comprehensive enough and. They felt it is positive towards inclusive education.

3.4. Discussion and Implications:

The developed inclusive teaching-learning resource could be an excellent contribution to inclusive education. Small steps taken by a teacher can make significant changes [2,9,12,13]. Lack of learning resources and lack of interest among teachers were found to be the reasons for V.I. students' education. In a way, the development of inclusive learning resources for all students creates sensitivity towards the education of V.I. students. A few scientific experiments have also been conducted with them to expand their interest in science. Students and teachers can record the readings of experiments using measuring instruments. The use of non-hazardous and harmless materials to develop learning resources increases resources for them. The learning resources were tactile in nature. Therefore, students can also use learning resources for self-learning and visualizing and understanding scientific concepts [10]. As most students with visibility can read and write braille, labeling the models and learning resources in Braille could have the most significant implications for them [3,6,11,23]. The llustrations with 3D effects would be better than those with 2-D effects [30]. In this line, student-teachers also tried to give a 3-D effect to models and charts that also help V.I. students develop cognitive scientific ability.

3.5. Few Recommendations:

- Proper implementation of the RTE Act-2009 and PwD Act 2016 [17,20], and strict follow-up recommendations of NCF-2005, and NEP 2020[15,22], and government initiatives can be crucial in creating a positive classroom environment for visually impaired students.

- Teacher autonomy is plausible if it includes the scope for choosing assessment techniques, teaching methodologies, and learning resources. The availability and access to audio and Braille books in the school library and student-oriented components should be welcome.
- Appropriate training for teachers, students, principals, and parents is essential before introducing policies or initiatives at the school level. Teachers should adopt alternative methodologies to teach students direct dialogue with them, hands-on learning experiences, and activity-based learning.
- Visually impaired students cannot see or partially see, but they can learn Science or other subjects by other senses. Teachers should channelize their interests. If they are interested in music, they teach science in an integrated way and make them understand the science behind music. Therefore, teachers must understand the interests of students and correlate them with science teaching.
- Group activities could be an excellent alternative for V.I. students in science classrooms before the teacher needs to develop social integrity among students. Thus, students can understand the importance of group activities and become involved in classroom processes. The teachers' role here is to make groups comprehensively keep in mind the students' needs and adequately guide students, specifically V.I. students.
- One of the biggest problems faced by them is that they cannot fully see pictures, text, or objects, but can feel them by touching them. A Braille Illustration Science Textbook could be developed based on the Kunz strategy.
- Government and schools can provide e-books and videos to visualize concepts and perceive information or knowledge through hearing. However, as they cannot see or partially see, the 3-D graphical representation of the structure and brail coding could be more fruitful. They can at least see and feel an object. Teachers and schools make audio tutorials and books available. Technology can be boon for them, and teachers can utilize it to develop resources and assist learning. They could listen to audio files. Many software packages and apps, such as audio and text readers, help them learn concepts.
- The concepts of science, especially Physics and Chemistry, are challenging for them, as they involve rigorous engagement in a visualization process. However, teachers can involve them by engaging in practical exposure. Visually impaired students may understand the theoretical part, but it is challenging for them to understand the scientific processes. Nevertheless, science teachers should make an effort to make them understand science. They cannot ignore their curiosity and interest in science because of the fear of unexpected events in the science classroom. For example, visually impaired students can do household activities. Society expects them to do their work on their own, such as cutting vegetables, preparing food, switching on or off electricity by their own. They are capable to do so, how can we exclude them from learning science. Science is connected to our daily life such as electricity and reaction to food ingredients etc. Through constant and rigorous efforts, science teachers can achieve the objectives of inclusion in the science classroom.
- Visually impaired students cannot draw a diagram of organisms of processes like the diagram of Heart. Nevertheless, they can explain the heart's morphology or anatomy if teachers illustrate the concept using a model of the

heart or a tactical picture of the heart along with Braille text. Likewise, they can identify non-hazardous chemicals from their smell. They can few chemical reaction even hear the noise of the chemical reactions. They can also perform physics with students' or teachers' assistance. This issue might not be faced during secondary classes until class X because of the nature of the curriculum and assessment system.

- Biology teachers can provide hands-on experience to V.I. students. Moreover, tactile modifications of preserved specimens and herbarium sheets of flora and fauna could enrich the learning experiences of them in biology. Teachers can also create tactile drawing sheets of flora and fauna, as suggested by Kunz in the early twentieth century. Teachers can also use technology in the form of multimedia, e-learning, and mobile learning to facilitate learning.

4. CONCLUSION

In line with the recommendation of national and international commitments related to inclusive education, the present discourse explores the scope of democratising science education. It can be made accessible to visually impaired students using inclusive learning models. The notion of discourse aimed at providing incentives to bring them to the mainstream. Teachers can cater to a broad range of needs of them using inclusive science model. It may also increase the understanding of all students in science and their knowledge. Science teachers can consider different ways of learning using models. It is not the researcher's intent to prove that such an approach is the only way that science education could be more inclusive. However, it is reasonable for science teachers to achieve goal of inclusive education in science.

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