STEM Education for Blind and Low Vision Students The Socio-Technical Challenge: The Indian Perspective

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Abstract

STEM education for blind and low vision students the world over, and similarly in India, has been held hostage to a combination of fear, doubt, lack of knowledge, lack of teacher training skills and resources combined to give the false verdict – It is not Possible! These views over time have found a way of being institutionalized as part of education systems. This in turn has had significant impact on lives and career choices of blind and low vision persons. When a trend or an experience becomes part of collective social consciousness for a long time, imaginations assume the power of truths relegating fact to the realm of fiction. XRCVC has been seeking a way to overcome these socio-technical challenges in India over the past years. This paper elaborates the journey so far. In sharing the Indian experience, the paper also proposes a model to address this socio-technical challenge which has the potential of replication in other settings worldwide.

1 Overview

The Indian Census of 2011 accounts for 2,68,10,557 persons with disabilities in the country†. Of these 50,32,463 belong to the category of seeing disability, which includes both blind and low vision persons. Of this group 11, 33,152 are in the age group of 5-19. This constitutes a large number of school and high school going blind and low vision students. Further, of the total seeing disabled population in the country, 35,02,590 live in rural areas whilst 15,29,873 reside in urban areas. *(Government of India (2011), Census of India.)*

With this as a backdrop, education for students with blind and low vision in India is a huge issue at hand. Not only are we coping with very large numbers, but given the urban-rural distribution, we also face the big challenge of taking the advantage of technological advances to the entire group.

Further to the number dynamics, the Indian education system is a multilayered set-up. With diversity of languages in the country, education systems also exist across mediums. English medium education has had greater aspirational value compared to other regional language education. In addition, India being a federation of states, where Education falls under the concurrent list of the

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† Census of India, 2011: http://www.censusindia.gov.in/2011census/population_enumeration.html

Constitution of India, makes it both a state and a central subject to be legislated upon. Each state has its unique education board, which has the freedom to create its own rules and regulations.

India passed the Right to Education Act in 2009 which made the right to free and compulsory education to all children up to the age of 14 a fundamental right under the Indian Constitution. This right has given Inclusive Education in a firm legal mandate in the country.

Further, India, as a country has also been driven to STEM education. India has been regarded to have the highest rate – 80% amongst the students of 16-17 years of age have an interest in engineering careers. Further, India has also shown the most reduced gender gap in engineering careers, where men show an interest rate of 85%, whilst women 79%, as against the other countries where women interest rates lag behind – China: 65%; Brazil: 55%; US: 35%; Germany: 33% (The Queen Elizabeth Prize for Engineering Report (2015) Create the Future)[‡]

Given this to be the nature of blindness and low vision population dynamics in the country along with the education system structure, STEM education for blind and low vision students is of crucial importance.

Access to STEM education for the blind and low vision in the country has multifaceted impact. Lack of access to it stems from multiple factors:

- Access to STEM education, the world over and similarly in India has been held hostage to a combination of fear, doubt, lack of knowledge, inadequate teacher training skills and resources combining to give the false verdict – It is not possible for students with blindness and low vision!
- Multi Lingual Indian Language education makes many of the accessible STEM technologies out of reach for students / teachers of non-English medium education systems.
- The large urban-rural divide makes the cost of and access to, technologies in rural areas, a continued challenge.

These combined challenges have a wide-ranging impact on the lives of persons with blindness and low vision:

- Lack of access to fundamental right to education.
- Restriction on career choices in higher education because of lack of school level mathematics and science education.
- Given the high aspiration of STEM careers in the country, the lack of access to the same for blind and low vision persons creates an increased sidelining and marginalisation of the group from the mainstream.

The Xavier's Resource Centre for the Visually Challenged (XRCVC) (www.xrcvc.org), a department of one of India's leading educational institutions, St. Xavier's College, Mumbai, has been working actively to address this crucial challenge. This paper outlines in detail the issues at hand, and XRCVC's work so far in addressing the same. In providing the Indian case study of overcoming the Socio-Technical Challenge in the field of STEM education for blind and low vision students, the paper presents an effective model which has the potential for replication elsewhere.

[‡] http://qeprize.org/wp-content/uploads/2015/11/QEPrize-Create-the-Future-Report.pdf

2 The Need

Durkheim has long argued that education "is only the image and reflection of society. It imitates and reproduces the latter…it does not create it" (Durkheim, 1897/1951: 372-373).[§]

When STEM education for the blind and low vision is scanned through this lens, it is difficult to refute Durkheim.

The traditional view within the education space, for teaching and learning of mathematics and science has assumed the over-dependence on sight for the same. The traditional mathematics classroom has been regarded as the epitome of the need for a board where the teacher can scribble the long equations and students can copy the same in order for learning to be possible. The same, when taken to science laboratories, has always regarded the need to see the colour change of a chemical in the labs as the most critical element of scientific learning.

With this mindset as the base, bringing a blind or low vision student into a mathematics and science class has more often than not been considered a taboo. "It is too visual!", "How will (s)he ever learn!" "What is the point of learning this now when there are no career prospects?"

These conversation trends have dominated social discourse, be it within families, schools and oftentimes within organizations working for blind and low vision persons as well.

Within India, over time, they found a way of being institutionalized as part of education courses.

Several education boards began permitting for exemption of students with blindness and low vision to take up regular mathematics and science as part of their 10th and 12th grade examinations. They would be either offered 7th grade mathematics or alternative subjects[**]. Whilst this was offered as a choice for students who wanted to opt for the same, it soon became the popular and mandatory thing to do. Schools who did not know how to teach would encourage parents to take the exception. Parents who were worried about high grades would take the exception out of fear. Over time the need for less work on the part of schools, and easier options for parents, resulted in a situation where if a student wanted to continue with regular mathematics and science (s)he was denied the same.

This subsequently had an enormous impact on students' career choices. Having not studied school-level mathematics and science, students automatically dropped out of eligibility criteria for higher education STEM courses. Careers by default had to be picked in the humanities or commerce fields. The spiral leading for a greater advocacy of encouraging students to drop school education, STEM on reaffirming, "No blind students take up STEM– hence it must not be possible."

The XRCVC encountered this spiral with one of its earlier batches of students graduating from the Humanities with diverse subjects such as Economics, Sociology, Political Science, etc. The students, having completed their graduation, wanted to pursue higher education in Management Studies. The entrance examinations to Management Studies courses needed them to know mathematics up to 10th – 12th grade, which on account of the earlier mentioned spiral these students had not completed.

It is here that the XRCVC began its journey in tackling the STEM Challenge in India. What we discovered since has come to reaffirm our belief that STEM is easily doable and possible, we only need to build the right environments: Human and Material.

[§] Durkheim, E. (1897/1951). *Suicide, A study in sociology*. New York: Free Press.

[**] Maharashtra State Board of Secondary and Higher Secondary Education provides the option of students taking up vocational subjects in lieu of Mathematics II paper. (http://www.mid-day.com/articles/state-finally-circulates-list-of-concessions-for-disabled-students/15448195)

3 The Initial Steps

XRCVC began its work when it first encountered the spiral by teaching and training a group of students for their entrance exams through group coaching format. When at the end of a year, three of the four students managed to get admission to their desired prestigious B school courses it was clear to us that if mathematics can be re-taught after a gap of 8-10 years, it most certainly can be taught effortlessly at the school level. Why was it then not being taught?

We began our inquiry through an action research project that aimed at identifying the key factors that had negatively affected mathematics and science education in India so far, and what possibilities lay ahead. The action research resulted in the publication of the XRCVC report titled 'Numbers and Reactions: A report on Mathematics and Science Access for the Visually Challenged'.

The research reflected crucial data with regard to the STEM challenge in India. Whilst there was a negligible percentage of students undertaking mathematics and science education in India even up to the 10th grade students with a keen interest and aptitude in these subjects had pursued them well into higher education and beyond despite a complete lack of resources. (XRCVC (2013), Numbers and Reactions: A Report on Mathematics and Science Access for the Visually Challenged)[††]

Our research also reflected findings of similar studies across other parts of the globe, that whilst there were some practical challenges in the study of STEM subjects for blind and low vision persons, solutions did exist to overcome the same. (RNIB, 2013)[‡‡]

This to us clearly reflected that the biggest hurdle was Sociological – Mindset and Will related, and less Technological. The question at hand therefore was how does one take mathematics and science education to the wide majority of blind and low vision students and not limit it to the select few self-motivated students, families and institutions.

4 Maths and Science Access Project

Through the past two years the XRCVC has been actively involved in addressing the key Socio-Technical challenges of STEM Education for blind and low vision students in India. The key challenges that were identified included:

- Absence of the right mind-set: The need for Awareness
- Lack of Resources: Skilled Teachers, Books, Concept Teaching Resources

Both these made the subject learning experience more difficult than it was, leading to students and parents attributing the difficulty to lack of vision rather than lack of resources. This, in turn, ensured that the spiral of myths "it is not possible!" continued endlessly.

Myths about the impossibilities fueled encouragement for students to drop out and discontinue STEM education at the middle school level itself. For the few students who did not drop out, lack of teachers trained in appropriate pedagogy and the lack of basic resources of books and concept teaching resources made things more difficult. This resulted in discouragement and dropping out of such subjects at the higher education level.

Thus, the biggest challenge to break this spiral was to find a balance between awareness generation coupled with ground level changes. In the absence of the two moving forward together, the ground level reality would always make things difficult which would never permit the large majority

[††] XRCVC; (2013): http://xrcvc.org/docs/making-numbers-and-reactions-accessible.pdf

[‡‡] RBIB (2013): Teaching STEM subjects to blind and partially sighted students: Literature review and resources: https://www.rnib.org.uk/sites/default/.../2013_05_Teaching_STEM.docx

to make the shift. Only when resource availability increases would the mass shift towards the changed reality with awareness initiatives.

This is the model that the XRCVC has strived to create, and it is at the early stage of deployment.

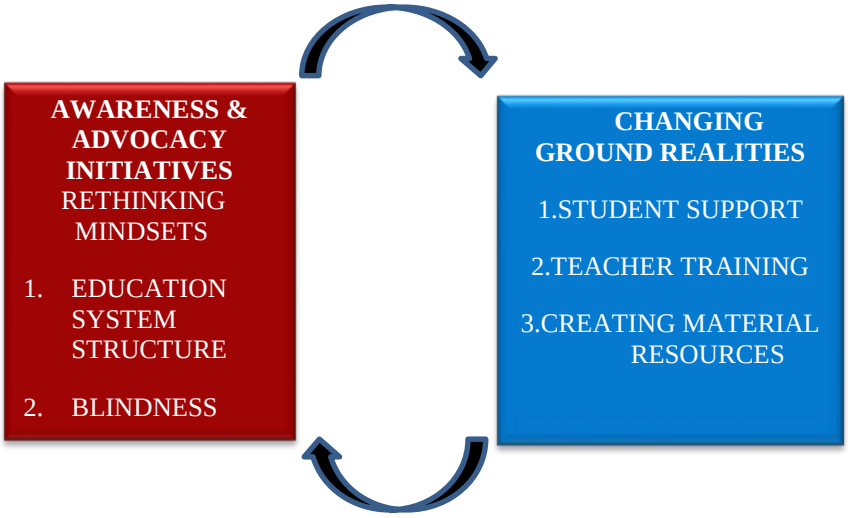

Figure 1: XRCVC Mathematics and Science Access Project Model

AWARENESS & ADVOCACY INITIATIVES

The awareness needs have been at two levels. One has been at the level of dispelling myths related to blindness and low vision: Enabling groups to understand the How and What of blindness. These efforts have aimed at spreading ideas on possibilities of scientific learning and careers for blind and low vision persons. Plus sharing existing success stories and demonstrating the possibilities.

The second aspect of the re-think has also been associated with challenging how education systems and work have been structured within the larger human understanding. The basic question that has been challenged here is, when do you say, “I have done this task”?

As our first students in Bachelor of Physiotherapy courses, Engineering courses make their way through mainstream formal education degree programs the constant question of “But how can we say he/she is doing it if they are relying on sighted assistants to either give them information about how a wound is taped, or put a chemical in a test tube?” keep coming our way.

When physicality of the task of putting a chemical in a tube is considered a greater learning point over knowledge of the chemical being used and the reaction at hand, then the battle is more about the ground of what our ideas on teaching and testing are and less about blindness.

When this battle of education interferes with myths on blindness, the combination becomes explosive. If teachers believe that blind students cannot study STEM subjects coupled with their belief that the only true test of learning and proving that “I have done this task” is the physical act of doing then we are facing a wall which is difficult to penetrate.

The XRCVC has been working on these through mass scale events, group workshops and advocacy work with specific institutes to help them formulate effective examination guidelines that test true learning over the physical act of doing.

Through 2009-2014 the XRCVC has been actively working through its social advocacy initiatives with the Maharashtra State Board of Secondary and Higher Secondary Education, Central Board of Secondary Education, Maharashtra University of Health Sciences, and others, and has managed to

start getting systems in place for effective examination guidelines in STEM subjects for blind and low vision persons[§§]. Some of these also necessitated judicial action. The related challenge in the light of education being a decentralized subject, where each board and university has the right to formulate its own guidelines, was the need to have a centralized policy. Only when a centralized policy exists would STEM education move towards a uniform access structure. XRCVC's work towards the same got the Ministry of Social Justice and Empowerment to issue uniform examination guidelines[***] that for the first time recognized the need for lab assistants in doing STEM examinations.

Several of these advocacy initiatives have succeeded within the legal framework of the Indian Persons with Disability Act (1995) and India's commitment to the United Nation Convention on Rights of Persons with Disabilities (UNCRPD) (2008), to which India was one of the first signatories.

CHANGING GROUND REALITIES

When through our awareness initiatives, individual students, families or institutions are reached out to who are willing to start the STEM education processes for blind and low vision students, the critical component of changing ground realities kicks in.

Here the challenges have been many, and we have tried to create strategies that help address the same.

When we first recognized the truth that without increased support at ground level the masses will not shift, the biggest challenge was, what kind of a system will be sustainable to meet the extremely high and diverse end-user need for a country like India. No single organization would be able to service a population as diverse and large.

That fundamental social reality of the country has driven us to create a model which would be scalable and sustainable over time. Our focus has been towards providing direct support to the number of students we can handle at the local level, with simultaneously delivering Teacher Trainings and building up of an open Concept Teaching Resource Library.

Student Support

The key component of the student support, especially in the area of mathematics and science learning, is both for the special educator as well as the subject teacher. The key for the student is in selecting the most appropriate reading-writing format for his/her situation. Most students with blindness and low vision, in the absence of a well informed choice regarding the same, find higher education in STEM difficult. Further, sometimes there also needs to be a format change depending on the standard of learning. This becomes especially true in today's context with the advent of computer-based mathematics now becoming accessible. Hence the right choice between Taylor Frames, Cubarithms, Nemeth Braille, LaTex with screen readers or a combination of these as the preferred reading and writing format is one of the most crucial element of the student support.

Subsequently the student support also needs to extend to the student appropriate methods of accessing visuals and diagrams. Once again entailing a choice from the variety of options - parchment paper with rubber mat, sewell line graphics, simple made-at-home graphics with 3D liners, 3D models, etc.

Eventually, a critical aspect of the student support also entails facilitating STEM careers for students who are keen and interested in the same. This has an additional element in the current scenario. Not all higher education STEM courses and institutions offering the same have Inclusive

[§§] http://xrcvc.org/docs/xrcvc-existing-examination-rules-across-various-education-bodies.zip: Circulars of various boards related to STEM education can be accessed here.

[***] Ministry of Social Justice & Empowerment, Department of Disability Affairs, Government of India, (2013): Guidelines for conducting written examinations for persons with disabilities: http://xrcvc.org/docs/msje-guidelines.pdf

admission and support systems in India. Hence advocacy processes form a key at this juncture to ensure that students get access to the education of their choice.

Teacher Training

A single organization can only reach out to limited students. This is especially true in work areas where resources are scarce. Teacher attitude and skills form one of the most crucial elements of successful learning experiences.

As much as there has been resistance of the classroom teacher in teaching STEM to blind and low vision users, the same has largely existed in groups of Special Educators for the blind and low vision as well. This has been true in India also because of the larger special education fabric in India. Due to the traditional exclusion of special education mandate in education programmes, it has never been regarded as a promising career. Entrants to the field have often been those who would not make it to mainstream Bachelor of Education courses and School jobs.

Thus there has been a need to work on updated skill and attitude training geared towards STEM education both amongst classroom teachers as well as special educators.

Further, the Indian education for students with blind and low vision is still divided between the Special School and Mainstream school models. Mainstream education for blind and low vision students is still in the Integrated education space and yet to make the active shift to Inclusion.

Hence, within the teacher-training programmes it becomes extremely crucial to address the diverse group of teachers on the ground level. These would include classroom teachers of integrated/inclusive schools, classroom teachers at special schools, and special educators who are out-of-class support in either of the setups.

The XRCVC has started delivering these training courses which aim to build skilled human resources over time in the area of STEM education for blind and low vision students over time.

Concept Teaching Resource Library

The availability of basic textbooks and teaching-learning material still remains a distant possibility for most blind and low vision students enrolled in schools. The Government of India has launched the Sarva Shiksha Abhiyaan (SSA) (Education for All) to uphold Right to Education. Whilst the SSA aims to supply accessible textbooks and teaching-learning resources to blind and low vision students enrolled in schools, the same remains an administrative challenge.

The XRCVC can reach out to limited students locally, and the Teacher Training workshops may augment the number of skilled human resources; however when the end-user base is as large as in India, there need to be systems that can enable any child in any part of the country to access basic teaching and learning.

With that aim in mind XRCVC's Mathematics and Science Access project has begun the process of creating an open source concept teaching manual library. The library aims is to have a systematic, searchable manuals broken down to smallest concept names for mathematics and science up to 10th standard available for use by all. Which means, whether you are a class room teacher, a special educator, a parent, a friend, or a student keen to learn and teach STEM topics to blind and low vision students but are stuck with the How, all you need is to download the same from the resource library.

This holds the enormous potential of upscaling in benefits not only to students in India but across the world. The Resource library is being envisaged as an open source system where educators from around the world can pool in with contributions.

In addition, the XRCVC has also begun the process of textbook content creation which has been largely missing in the country especially in electronic formats for higher education which is the preferred format choice for those levels.

So with the two verticals feeding into one another the quantum shift in mindset and reality, from "We are scared, it looks impossible" to "Let's try, it seems possible" is likely to happen sooner rather than later.

5 The Road So Far and Ahead

When a trend or an experience becomes part of collective social consciousness for a long time, imaginations assume the power of truths relegating fact to the realm of fiction. That is what STEM education for blind and low vision has been subjected to. These misconceptions pose the biggest challenge in transforming higher STEM education for students with blindness and low vision.

As an organization convinced about the need for STEM education at all levels, not only as a basic pillar for holistic education but also as a right of choice over one's career, the XRCVC has been striving hard to start a wave of change.

Myths that have become entrenched in the social psyche need time to be plucked out one at a time and be replanted with new and current reality-based ideas.

Over the past two years, the project has seen the country's first totally blind student completing her Bachelor's of Physiotherapy Degree from one of the leading Medical colleges / hospitals in Mumbai, India. At the same time one of our students has also needed to cross the oceans to the University of Stanford, USA to pursue Computer Science, as the Engineering Institutes in the country were not ready yet.

Our challenges remain endless and at the same time many more doors continue to open. Technological advances have come a long way in making things possible for blind and low vision students to independently access STEM subjects. The biggest challenge of today remains in the human mind, whether we will adapt and change to these new realities or continue to ask the old questions.

We hope that with our resource libraries, training programmes and awareness efforts we will be able to reach a point of critical mass in the journey over the next few years that will compel the current walls to break and make the shift themselves or the critical mass will demolish them charting its own path.

In addition to these, for nations like India with multi lingual user bases, cost is still a big factor to enable access. Even though solutions exist, the list of technological challenges are also far from being fully overcome. Efforts to bridge this cost factor have begun in projects like ASSISTECH[†††] that aim at creating low-cost teaching-learning resources and technologies. Further the Government of India has also started special schemes like Assistance to Disabled Persons for purchase/fitting of aids/appliances (ADIP scheme)[‡‡‡] that aim at making available the latest assistive technologies at subsidized / no cost basis to students falling in certain socio-economic sections.

The future of STEM education for the blind and low vision students in India holds enormous possibilities. It not only has the potential for opening up a career choice for blind and low vision persons that has traditionally been denied but will also serve as a proof of concept on how human societies are always capable of changing landscapes without being mired in the dogma. And it further provides the space for the field of assistive technologies to expand into completely new realms of low cost, multi lingual solutions.

[†††] assistech.iitd.ernet.in

[‡‡‡] http://disabilityaffairs.gov.in/upload/uploadfiles/files/sipda/adiprevised010414.pdf