Getting towards the ARC: Needs Assessment Study

Introduction

India is home to over 1.1 million children with visual impairment (CVI) in the school-going age (5-19 years). However, only 68% of them attend school (Dey et al., 2018). Within the school-going CVI, the prospects of pursuing science and math in high school (beyond Class 7) remain bleak (Taraporevala, 2016). In the state of Karnataka, out of 45 schools across 31 districts, only one school offers Science and Math in high school.

Within the school-going CVI, enrollment for science in higher education remains abysmal. According to a study on students with disabilities across 294 colleges in India, enrollments in the science stream were the lowest (Jameel, 2011). The low enrollment could be attributed to the lack of adequate pedagogical resources in science and math, preventing students from taking up science in high school and beyond. For instance, Vision Empower conducted an ethnographic study examining the ecosystem of science and math education in special schools in India. Insights from the study uncovered systemic issues that shape the learning experience of the CVI in schools across Karnataka (Dey et al., 2018). Highly visual concepts of science and math (for example, geometry, water cycle, etc.) remain inaccessible to the students if the schools are not equipped with appropriate accessible resources and tools. In addition to this, the schools systematically discourage students from taking up science and math beyond Class 7 by making the subjects optional. The lab experiments are also omitted from the classroom learning experience.

Recognizing the needs of students and teachers, Vision Empower has been further invested in bringing about a complete overhaul of the state of education for CVI through pedagogical and sociotechnical interventions. Through grassroots interventions through a network of school coordinators and resource persons, the organization has been addressing some of the pressing challenges in the domain of science and math education. On pedagogical and curricular front, Vision Empower has been disseminating teaching learning materials (TLM) through STEM and Computational Thinking (CT) kits to special schools. This has facilitated learning and empowered school teachers to impart quality education to CVI. To compliment this, Vision Empower developed “Subodha” app – an accessible learning management system that provides scaffolding to teachers by providing guided tutorials and lesson plans corresponding to individual grade and subject. In addition to their flagship offerings, Vision Empower has also expended efforts in textbook remediation to make existing curriculum content accessible to CVI.

Beyond the pedagogical interventions, Vision Empower – driven by the ethos of participatory action research, has made great strides in the design and development of Assistive Technologies (ATs) in the sociotechnical context of India. Notably, in order to promote braille learning among early-stage CVI, VE co-developed HEXIS, an affordable refreshable braille display for promoting braille literacy among CVI. Along the same lines, VE also addressed another crucial component of science and math learning by co-developing another AT - IRIS in collaboration with Vembi Technologies. IRIS is a handheld TV-remote-sized product designed for CVI to explain the tactiles in audio format through braille embossed keys.

These technology and pedagogical offerings are complimented by critical human infrastructure (Sambasivan & Smyth, 2010) comprising resource persons and school coordinators who closely work with the teachers not just to facilitate AT integration in classroom settings but also to ensure effective pedagogical reforms through interactions with the teachers. As a result, VE has been making significant inroads in the landscape of STEM education in special schools. Today, VE serves 14 states, touching the lives of thousands of students with visual impairment.

While these interventions have brought about considerable improvements in various facets of classroom learning, the challenge of experiments-driven learning of science persists. For instance, when the subject of science is introduced in Class 5, students encounter barriers to learning as the curriculum includes activities and experiments that are not always accessible to the students. A systemic audit conducted by the Vidhi Centre for Legal Policy revealed that over 40% of grade 8 and grade 10 NCERT textbook syllabi had activities that were inaccessible to CVI (Vernekar et al., 2019). To make matters worse, there were no alternate activities prescribed for the CVI, thereby leading the teachers to skip those concepts. Activities form a crucial element of learning science and math. Through interactive methods, activities instill curiosity and make for an immersive learning experience.

Acknowledging the urgent need to address the issue of inaccessible resources, the New Education Policy (NEP) 2020 endorses setting up of resource centres for engagement and capacity building of special educators. This compliments the existing scheme of Samagra Shiksha wherein inclusive schools are equipped with Teaching-Learning Material (TLMs) for personalized learning support for CVI with special needs (*Learning For All: Equitable and Inclusive Education*, 2025). In line with such policy initiatives, a logical next step in the journey of Vision Empower is setting up of an Accessible Resource Centre (ARC) that provides an inclusive learning space to conduct science and math experiments and provides an avenue for teacher training sessions. In line with the NEP 2020, ARC is also envisioned as a space for engagement and capacity building across different organizations so as to bridge efforts in the domain of accessible education.

Towards this endeavor, it is paramount to understand the existing initiatives around science and math experiments as well as outdoor learning experiences that have shaped the learning of science and math for CVI in special schools. This report serves the following objectives:

- **Investigate current pedagogical practices adopted by the teachers for science and math concepts**
- **Identify and analyze previous/ongoing initiatives that teachers have found helpful in enhancing their teaching practices**
- **Identify the critical needs of the teachers in special schools in Karnataka**

With these objectives, the broader goal is to identify key needs and leverage existing models of programs to scope out future ARC programs. Through interviews with teachers from 10 special schools across nine districts of Karnataka, we examine the science and math learning experiences shaped by school infrastructure, available TLMs, and targeted interventions around experiential STEM learning. This work paves the way for the effective design of accessible resource centre.

Background: Learning science by 'doing'

Learning of science is best characterized by measuring, recording, analyzing and interpreting data from phenomena. The process thus necessitates learning by doing experiments and activities. A study conducted by Mensah (Mensah, 2015) posed a comparison between activity-based method and lesson-based method of teaching science concepts – acids, bases and salt and found that an inquiry-based, practical-driven learning result in a better understanding of scientific principles, enhances retention of concepts. A hands-on approach involving students handling the equipment and conducting experiments leaves a deep imprint in the minds of students and they learn to form associations between the concepts and the phenomena under investigation (Blough & Schwartz, 1990). A good science teaching practice would therefore involve teachers encouraging the students to gather data, experimenting and providing explanations (Collette & Chiappetta, 1984). When a teacher shows a demonstration of the experiment using equipment, students are excited to replicate the experiment using the equipment and comparing results (Farrant, 1980). Notably, within the experiment-based learning, group work has been reported as an effective approach towards learning science concepts in high school (Yardley-Matwiejczuk, 1997). Role play involving students becoming "scientists" leading investigation has been reported as a useful strategy to engage the students, turning them into scientists involved in simulations working in different scenarios (Erinosho, 2008).

Thus, it is amply clear that a good science teaching practice entails experiments, demonstrations, practical sessions. With this understanding, it is important to aim for equitable learning experience for CVI. Participation of CVI in hands-on facet of a laboratory experience has historically been considered unsafe by the teachers (Supalo, 2012; Swanson & Steere, 1981). Prior research by Vision Empower revealed how science topics involving chemical equations and experiments are omitted by the teachers due to perceived difficulty in understanding the concepts by the CVI (Dey et al., 2018). Echoing this, Mensah (2015) has shown how chemical processes such as balancing of chemical equations are particularly difficult due to its abstract nature, leaving a profound adverse sentiment around the subject.

Despite the historic hesitancy around the setup of a science lab for CVI, there have been some interventions that closely resemble the vision of establishing an accessible resource centre. A study conducted by Tsinajinie et al., (2021) reported one such program involving accessible science learning through outdoor visit to an experience centre. Spread across 5 days, the students explored concepts such as environmental science, chemistry and astronomy using assistive technologies (such as LabQuest, Perkins Braille Writer, ZoomText among others), models (such as sun, crater, soil basin) as well as real world objects (including knife, stapler, tactile graphs). The team that facilitated the program involved graduate students working as interns and instructors, subject matter experts, and volunteers. Various assistive technologies, models and real-world objects were identified for each concept that was taught using activity. Over the course of four days, the students investigated a hypothesis, collected data, conducted experiments. This was then followed by presentation on the last day of the program. With appropriate scaffolding, planned schedule, resourceful materials including ATs and pedagogical tools collectively offered a multisensory learning experience that enhanced collaboration, interdependence. In this study, the use of Talking LabQuest is noteworthy. LabQuest is an invaluable AT (Supalo, 2012) that allows students to collect data and measure a phenomenon. It has a range of capabilities including measuring pH, detect light, magnetic fields, motion and current. Talking LabQuest is an accessible solution that response to audio input. Besides such standalone sophisticated devices for measurements, an android phone with its in-built sensors could also be leveraged for conducting experiments. For instance, a study conducted by Gomes et al., (2023) demonstrated the use of Phyphox, an application that uses in-built sensors to calculate and measure values such as force and friction. Their setup comprised of a desktop connected to the mobile phone mounted on an incline plane. Similarly, the Phyphox was also used to simulate waves as a function of the intensity of light.

Yet another study reported an activity around the concept of an electromagnet Akarsu et al., (2022). Through principles of universal design for learning (UDL), the activity was split into different lab stations. Each lab station was equipped with a set of magnets and instruction set printed in braille. The range of activities were sequentially posited to make for a progressive

learning experience – beginning from the description of the problem statement and theoretical concept, then leading to the properties of magnet before finally designing an electromagnet. It is evident that tactile-based STEM activity, when distributed into specific microlessons offer a incremental learning trajectory around specific concepts.

These studies offer promising prospects of leveraging assistive technologies, pedagogical resources to enable accessible science and math lab experiences for students to learn the concepts through practical activities.

We now describe the research methodology and participant sample for our study.

Methodology

The study involved in-depth interviews and observations with teachers and a focus group discussion at our annual Pragya Teacher Training session. The fieldwork was conducted from July 2024 to December 2024. The researcher was accompanied by Kannada language translator to facilitate the interviews. Participant recruitment was facilitated by the school coordinators who obtained prior consent from the principal of the school to participate in the study. Data collection included interview notes, pictures, videos, audio recordings. Before beginning the interview session, verbal informed consent was sought from the participants upon which the interview session continued. They study is approved by the Institute's Ethics Review Committee. Participation in the study was voluntary with no monetary compensation. Interviews were primarily conducted in Kannada in coordination with the school coordinator. The online interviews were conducted as per the convenience of the participants (with platforms of their choice – Gmeet, Zoom, Call, WhatsApp) and duration ranged between 23 minutes to 120 minutes.

The data comprises of interviews with 24 teachers (11 female, 13 male), 4 principals (all male) across 10 schools in 9 districts of Karnataka. Average age of the participants was 44 and had an average of 14 years of experience. 13 Teachers did their primary schooling from a sighted school with limited resources to study science and math. 18 participants had obtained a degree in special education. A total of 9 teachers taught geography subject while the remaining were rotating their duties with other teachers in the school. 10 teachers taught science, 12 teachers taught Math. Given the low teacher-student ratio, it was common to witness one teacher teaching multiple subjects through the week. Each period of science and math was about 40 minutes.

Findings

School Infrastructure: A Continued Bottleneck

The school infrastructure and resources continue to remain a bottleneck, with limited government funding and attention. There exists a spectrum of schools with varied access to resources. The physical infrastructure of the school itself is not conducive to learning, with science lab being dysfunctional. The figures below shows a science lab in a government school in Bengaluru.

Fig 1: Science Lab room at a government school in Bengaluru

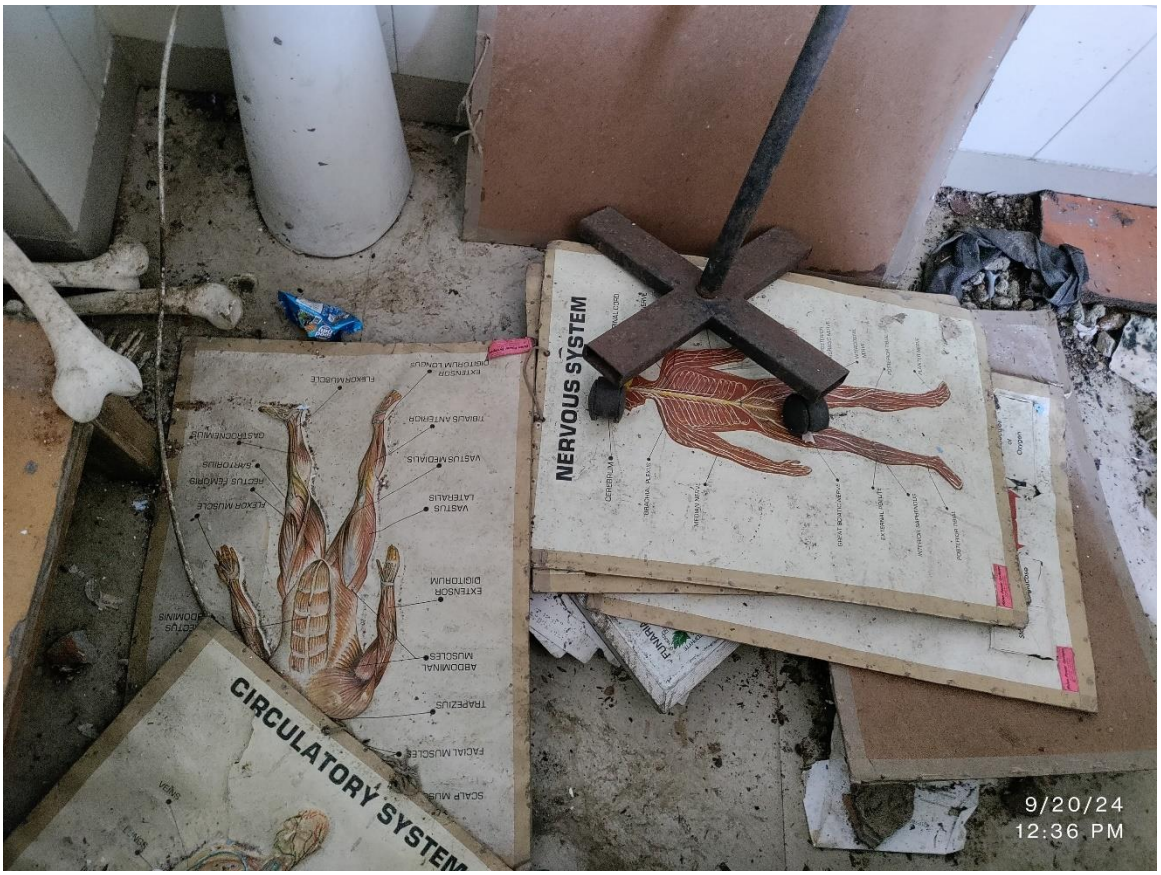

Fig 2: Educational charts lying on the floor at the science lab

This was not a rare sight as some of the other schools lacked proper infrastructure. Upon further interrogation with the principal and the administrative staff, the plight of government-run schools were revealed. The administrative staff at Chikballapur explained how they primarily had to rely on government grants which were often not sufficient for basic infrastructure. The role of NGO such as Vision Empower became crucial in such instances,

"The government does not lay much emphasis. It is mainly through the NGO that we get the support. There are grants based on which we get some money from the government but that mostly covers residence and food. Basic resources such as braille books are also provided by the NGOs….I always look forward to the VE TLMs as they help me a lot." (P2, Chikballapur)

On the other hand, there was a remarkable in some of the private schools. These schools had their own mini-version of resource centre – which includes both the learning materials provided by Vision Empower as well as those procured by the teachers independently. Figures below show the school resources shared by the teachers

Fig. 3: School teacher showing the different models available at the school.

Fig. 4: Shelf containing range of Teaching Learning Materials to teach science and math

Such contrasts in school infrastructure necessitate a systematic approach of addressing deficits in schools that do not have appropriate infrastructure and provide additional scaffolding to others who are reasonably equipped with some resources. With the establishment of a shared space in ARC, there lies an opportunity to play a level playing field to provide equitable STEM learning experiences.

Tapping varied experiences of STEM learning among teachers

For most of the teachers, learning of science and math was inaccessible growing up. Despite a genuine interest in the subject, the lack of appropriate resources prevented them to study science beyond Class 7. When it came to decision about chosing specific stream, Teacher T1 had not option but to opt for Arts. She said,

"Anyways, I would study only the theoretical parts because otherwise if you see science is a difficult subject for people with visual impairment. There are lots of diagrams and experiments. So, after Class 10, I took Arts because there are no practicals in Arts." (T1, Bengaluru)"

T1 further adds that had the current approaches involving tactile resources been available she would have loved to opt for science. Contrasting this Teacher T13 from Haveri recounts her school days that were filled with lots of activities,

"In classes 5 to 7, I had a sighted teacher. She taught almost all the concepts through some hands on activity. For example, heart – teacher explained using cardboard sheet. She explained heart, its size, and the functioning of a heartbeat and the shape which is like a mango. So, they used to explain like this. We used to learn like this and I was very happy." (T13, Haveri)

For others such as T4 at a school in Sidlaghatta, the joy of learning came much later in their life when they enrolled for a teacher training session.

"I was formally trained in special education at the [school name], where they encouraged us to touch and feel everything and that became integral part of the teaching practice. There were braille, embossed maps that were introduced and we were taught these resources for us to use and teach them to our students. (T4, Asha Kiran, Sidlaghatta)

As described by T4, prior learning sessions paved the way for their current pedagogical practices as they taught science and math to CVI. The teachers would get an opportunity to revisit science concepts as they enrolled for teacher training sessions by NGOs. While the teachers did not have a formal training in science, immersive program spanning multiple days provided an avenue for them to develop new skills and get new ideas…

"We get training to teach the concepts such as plants practically through tactiles. We went to NAB recently for a two-day training…The training centre is helpful for developing new skills and get new ideas" (T22, Tumkur)

Therefore, besides just patching up infrastructural gaps, a collaborative setting afforded by ARC also promises to enhance interactions among teachers from different schools. Reflecting on one of the prior experiences, a teacher emphasized on the need for a collaborative learning experience with other fellow teachers. She said she made it a point to attend any training opportunities. She says,

"I once gave explanation about the concept of breathing to other teachers who were attending workshop. And other teachers also had their own experiences and challenges. So, that collective experience with other teachers was very helpful in knowing more about how to teach the concepts to the students." (T5, Mysore)

So, beyond the formal training, a collaborative avenue helped her in learning from other teachers and she expressed interest in attending more such meetups.

Insights from prior research resurfacing as teachers shared their challenges

Some of the prior research that highlights challenging aspects resurfaced as teachers shared their challenges in everyday classroom settings.

When it came to teaching science and math concepts, teachers had to exercise caution as different students had different pace to grasp the concepts with many students needing multiple repetitions of the concepts to be able to understand in its entirety.

"Some students are not able to learn braille because their hands are not supportive. They don't have strength to use stylus and they don't have touching sense also, they cannot feel the letters. So, for those students, I have to make remember all the lessons. So, I have to teach orally again and again… After teaching 4 days, I may be able to cover half of the lessons so it is too difficult. " (T1, Bengaluru)

Moreover, the teacher-to-student ratio did not help the cause as they managed multiple subjects,

"There is shortage of staff, so we have to teach multiple subjects each year…Subjects are more, teachers are less. Sometimes we have to take combined class. When in groups, we can give general coaching. Individual assessment is difficult. Giving individual attention is challenging. (T22, Tumkur)"

The decisions around conducting specific subject lessons were arbitrary as T1 began teaching science as she knew English and could therefore read and teach science fluently. For T2, the teaching responsibilities made her to skip certain concepts while teaching.

"I have to skip some topics. Day to day what is required, only those things I will teach. All these advanced visual concepts such as geometry, trigonometry, etc. I have to skip. (T2, Bengaluru)"

While the significant workload overwhelmed the teachers, they acknowledged the pivotal role of the school coordinators

"I am handling 12 subjects but still I work with VE coordinators to complete the syllabus. Workload is a lot. 5,6,7 maths and science, kannada and class 8,9,10 I teach other subjects. So, I do teach multiple subjects and in the evening I teach braille. And I also teach CT games, etc. So, I have to manage time well. But I am happy to do that with VE support. (T13, Haveri)"

Besides the individual connect with the school coordinators, the provision of teaching learning material (TLM) has also helped teachers in conducting their classes. T3 noted how the TLM improved math performance of the students and instilled curiosity. TLM provided a shared vocabulary to articulate and understand math concepts.

Teaching Learning Material as pedagogical tools

Teaching Learning Materials provided by Vision Empower were clearly helpful for the teachers and came handy while teaching various concepts. For instance, a teacher from Shimogga shared how the availability of TLM real objects increased curiosity among the students and brought about significant difference.

"Nowadays, there are a lot of materials and aids to teach. Even Nagarathna madam is sending materials. With real objects, they are also getting interested in learning the subject more. They are curious. Earlier, they just used to listen, but with the materials, it has helped with learning and curiosity." (T9, Shimogga)

In the Focus Group Discussion, teachers highlighted how some of the TLMs needed to be revised. For instance, the size of the Animal models were too small and fragile, making it even more vulnerable in case of wear and tear. At the same time, there were instances of teachers enthusiastically sharing their innovative methodologies to teach specific concepts. A Mysore-based teacher shared how she used everyday objects to make Teaching Learning Materials (TLMs),

"We have some beads and golis to teach some things. Diwali is coming, so we also use the firecracker waste in making the teaching aids. We wash the stick and place the beads using a thread. We would also play a multiplayer game, wherein one student would be a bank manager

and two students would be customers and a student would be a cashier as well. They would be playing the game through conversation. A customer comes and ask for some rupees and bank manager would have their reply…so like that we teach addition subtraction, etc. It is used to teach place value concept. I take a thread and beads….So, it is very engaging and they start mentally they start thinking creatively and they relate the concepts to the real-life context." (T8, Mysore)

Sharing of such knowledge around TLMs and the nuances around teaching methods could be widely shared to other teachers and spark up conversations around TLM enhancements. Instead of a unidirectional provision of TLMs to school teachers, a collaborative dialogue around TLMs could serve as avenues for enriching pedagogical tools. This is particularly essential to address the disparities between what is currently provided vis-à-vis what the teachers need, as one of the teachers articulately expressed,

"What you think, sometimes we would not use those things. What we want, you wont prepare."(T24, Tumkur)

Above remark also spotlights the dearth of TLMs that are well aligned with the curriculum. While attending a session on Geography, she was quick to note that while there were lot of maps that teach concepts of world, India, Karnataka – these maps did not cover textbook syllabus of historical concepts linked to the geography – such as the Mauryan Empire. Her demand for inclusion of such concepts highlight a need for more resources that are contextualized to the syllabus. Some of these concerns around resources were also shared at the Pragya Teacher Training session where she also learnt to make TLMs from waste materials through a tutorial session conducted by Prof. Saswathi.

"I teach the students the concept of globe, etc. to Class 6 students. But when she showed scale and everything practically – I learnt and enjoyed. I did not know how to make the globe and measure latitude and longitude. She taught me that day. Personally, I asked and she taught me. I came to know how from 0 to 360 degree – how to measure using locally available materials using the toothpicks." (T24, Tumkur)

Teacher training sessions that spanned multiple subjects were very much appreciated by the teachers as they equipped them with unique instructional strategies which they were now excited to adopt in their classes.

Assistive Technology in Schools

Schools had a set of desktops, equipped with screen readers that provided a foundation of computers to the students. This was essential part of the classroom learning as teachers iteratively taught the effective use of computers.

“I first teach the students, basic keyboard orientation, typing, desktop orientation. Once they feel ready, I make them do typing practice. And as they gain confidence, we explore Google Chrome and other internet based services.” (T1, Bengaluru)

While schools were equipped with assistive technologies such as Annie, Perkins Brailler – most of them remained unused.

Fig 5: Unused Annie Device at the “Annie Smart Class”

AT device Annie required extensive configuration by the teachers and involved a steep learning curve. This prevented its use in the classroom settings, despite a dedicated room being allocated for Annie-device based explorations. Upon asking about the unused Annie device, the teacher explained how she felt perplexed by the device in the absence of a formal training.

“They [Donors] had provided us with Annie. I have heard that it is very useful. But it has a lot of buttons and features and I don’t know how to use it. So only we are not able to use it. First, we should know only then we can involve the students.” (T1, Bengaluru)

It was this lack of training that rendered the device unusable in the classroom settings. Similarly, teachers hoped to gain more knowledge and become proficient in various AT offerings. For instance, T13 hailing from Haveri shared,

"I have just seen talking calculator. But I don't know how to use it. If there are training sessions, then it would be very helpful to know what are these tools and how it can help in specific maths concepts. (T13, Haveri)"

Despite AT non-use, teachers attributed training programs for learning about new technologies. T7 from Gulbarga shared how he came to know about AI and its application during a recent training session conducted by Vision Empower,

"In the Pragya, Vidhya showed us about the tree and class photo she took and explained the use of BeMyAI..so nicely it explained even small details about colors and everything. I think AI is helpful in color identification and more. Earlier, I used to just tell them "water of color is blue", or "forest has green color". But, now AI will give so much information. (T7, Belgaum)"

in my discussions with the teachers, they were excited about having a dedicated space of ARC for such training where they are not only trained with regard to the technology but also to integrate it with the curriculum. This was also observed in the case of the Teaching Learning Materials. In the Focus Group Discussion held at Pragya, teachers shared how TLMs existed but they did not know how to best use it in their teaching.

Thoughts around an accessible Science Lab

When asked about the initial thoughts around a science lab, teachers were hesitant of the idea pointing about the safety hazards that this might entail. Notably, Chemistry was one of the main concerns owing to the chemical compounds and the reactions. T18 explained that while it was important to identify the different compounds, but conducting an experiments may be difficult for the CVI:

"If there are two liquids, they will identify it as liquids but what liquid it is and the distinction is a bit difficult to imagine. Suppose there is water and butter milk, how can they recognize that they are different? Suppose, it is acids and bases – how can they taste it? They just cannot so liquids and chemicals are difficult to learn for the students. Smell is a possibility, but then it is dangerous. (T18, Mysore)"

However, this idea did not resonate with everyone as there were schools who had been making efforts in providing a lab experience to their students. For T3, the vision of a science lab was already in the works. While not a dedicated room, he showed a space in the staff room which was dedicated to all the TLMs provided by Vision Empower. He further shared,

"So there would be tactile maps, materials and a showcase. We will have different concepts stuck in the wall. It would be written in both braille and for sighted people. It would be for Class 6,7, and 8. And along with that we will also have all the equipments that VE has provided. We are dependent only on VE aids. (T3, Sidlaghatta)"

This was echoed at other schools where there was a “VE corner” which was equipped with the TLMs, especially 3D models. However, when it came to conducting experiments, even such schools had their share of reservations.

While an accessible science lab seemed to be a distant thought, the teachers appreciated the vision and recollected their experiment-based activities performed at the Pragya Teacher Training sessions.

“There were many topics. I learnt about respiratory system and I was active in learning through experiments using balloons. What is normal breathing? And how does breath vary when we are tired? Even I gave explanation to other teachers who were attending Pragya. Other teachers had their own experience. So, that collective experience with other teachers was very helpful. (T5, Mysore)”

It is noteworthy that teachers also enjoyed the company of other fellow teachers who had joined from different schools.

Besides Vision Empower, schools have been collaborating with other external programs to have experiment-based learning lessons. Two notable examples that came about quite often were Vividha Trust’s “Curious Minds” initiative and Agasthya Foundation’s Mobile Science Lab. Both of these fared well when it came to giving some experiential learning to the students.

“Agasthya has good activities…about electronics, digestive systems, litmus paper, etc. They do science liquids – separation of compounds using filter paper. Density of liquids. Separation of components using filter paper. Some dust is there in water. We cannot separate it. But if we take the filter paper, then it is separated. We have one class of lab for Class 6 and 7. They will do 1 chapter each. They have given some topics. They told they would do circuits and motions also. (T20, Mysore)”

Vividha Trust’s initiative Curious Minds has been particularly beneficial for the students learning about different science concepts using experiments.

“Vividha conducted online experiment. They showed some experiments such as energy, sublimation from students. We gave some materials – TLMs and they are very interested. And they wanted to do the experiments as a part of amazing energy, sublimation. In maths, there was fractions, tailor frame HCF, LCM, addition of fractions, etc. In science, motor cycle, color discussion, volcanoes. They are learning all these concepts through activity. For volcano, there is a chart which is prepared with some assistance. TLM model is made using a motor – how blind students can learn volcano. After that, I showed it in the Curious minds. About 5-6 experiments are there which are conducted by the students. (T9, Shimogga)”

Outdoor Learning Experiences

While a school may not have had an accessible science lab, the students have been engaging in other outdoor learning experiences that provided them with an experiential learning. Teachers shared that the students were always excited to meet new people and it also provided an escape from the monotonous classroom lecture-based learning method.

One of the schools even collaborated with a sighted school for providing a better learning prospects for the students.

"A school nearby conducts experiments… Students visit the schools to conduct some experiments. Only Class 6 and 7 have gone there… They got to new school, it was a new environment. The experiments were conducted with permission from HM and the science teacher of the school. Sighted teachers explain it initially. If the students do not understand then they will teach. Suppose oxygen is prepared – how it is prepared? By igniting spark, there will be some sound that would be coming. Oxygen is present and hydrogen is released. So, such kind of experiments are there." (T4, Chikballapur)

Experiments also involved identifying carbohydrates, protein, vitamin, etc. in food. We used to touch wheat, rice, etc. – all eatables by touch and feel. Such collaborations enabled the CVI to learn concepts in a more engaging manner.

Effective Pedagogical approaches

Teachers identified few important pedagogical approaches through which students learnt most effectively. This included

a) Story based scenarios
b) Roleplaying characters (such as banker, scientists)
c) Skit/Drama
d) Competition

Competitions were a salient aspect of learning. Teachers emphasized the role of competitions in attaining learning outcomes at par with the sighted students.

"They had a competition in their school…and sometimes they would even participate in competitions with the sighted schools. For VI students, this is important, because when they visit sighted schools, and when they see those competitions – they will also learn through the sighted students. They will feel that we are VI but we can do everything at par with others. So, it is important to have competitions with the sighted peers as well. We are VI but we also have learning ability and IQ to learn science. (T13, Haveri)"

Further elaborating on the cascading effect of competition on other school students, T13 explained,

"Competition is very important for retention. For instance, a couple of students went to Mysore for competition. And when they come back, they talk to other friends and other students and share their experience of the overall atmosphere and how they were treated, it will be helpful for both – not just those who visited but even to those who listen. ***Next time, other students would be motivated to go to such competitions and they will study hard and have better prospects of a good future.*** *When they come and share their positive experience, others will be motivated…next time other students would be motivated. Especially if they win some prizes. , say Rs. 1000-1500."*

Topics that are difficult for the CVI students to learn

Teachers broadly identified few specific topics that were particularly difficult for the students to learn owing to lack of appropriate pedagogical resources.

1. Growing of sprouts
2. Holes in a leaf during photosynthesis process
3. Geometry shapes
4. Surface area and volume concepts of 3D shapes
5. Acids, Bases, and Salt
6. Measuring scale of water body, physical structures
7. Optics and Light
8. Current and circuits
9. Spatial understanding of atoms, compounds, molecules

Recommendations for ARC

Vision Empower has been committed to achieving four primary goals to meaningfully impact the STEM education across special schools. This include (a) Providing accessible resources including teaching learning materials (TLMs), tactile diagram books; (b) Support teacher using teacher training sessions and orientations from the resource person. ; (c) train the teachers and students in contemporary assistive technologies and impart foundational digital literacy; (d) Foster an ecosystem that works for providing STEM opportunities for students with visual impairment.

Towards this cause, insights from the field reveal exciting opportunities that could be materialized with an Accessible Resource Centre (ARC). We elaborate on them based on Vision Empower's goals.

Providing Accessible Resources

a) Alignment with textbook curriculum and existing pedagogical practices

The suite of Teaching Learning Materials (TLMs) offered by Vision Empower has benefited the schools and reshaped instructional practices of the teachers. Recounting previous experiences around teacher training sessions across different organizations working towards accessible education, teachers reiterated the need for the TLMs to be designed as per the curriculum with an incremental progression of topics.

One of the teachers pointed that while the concept of maps was described through the tactile diagram book, it was not catered towards the specific syllabus. She noted that most tactile diagrams of maps primarily revolved around physical map of India, political map. Contextual maps around history were left unattended. For instance, while the textbooks had information about the Mauryan Empire and their spread across the geographical region, she did not come across tactile diagrams related to historical maps. Correspondingly, the 2D and 3D models that explained the concept of map also did not have anything specific to such topics.

A dedicated program to review TLMs and existing instructional practices could help bring to the fore the limitations of existing TLMs and textbooks to systematically ideate alternate approaches. Each subject may have unique needs which could be best identified in a workshop setting with teachers from different schools participating and sharing their thoughts around the curriculum.

Moreover, while most schools had braille textbooks, teachers reported that the textbooks were also regularly updated each year. Some schools faced issues with unavailability of latest math textbooks. An annual textbook review may help facilitate textbook access for the school students. Unavailability of textbooks could be reported to other organizations in the ecosystems. Furthermore, one of the teachers faced issues while reading chemistry textbook that were filled with chemical equations. The lab manual instructions and the chemical reaction processes were not easily understood. While designing the lab manual, there should be an explicit focus on the learning outcome, intended grade, and activity description. The explanation of the activities should go beyond mere braille equivalent of the text and special accommodations must be made to enable orientation of advanced concepts.

b) Effective models of engaging students while learning

All the teachers suggested that a participatory activity went a long way in retention of concepts as it emphatically enforced the learning outcomes among the students. Teachers reported effective activities that were helpful in learning contexts. Similar model could be leveraged to tap into the experience of the teachers as we design activities in ARC. These models include:

- Competitions: Students at S1 were all elated when asked about their outdoor visit experience. They instantly recalled how one of them had won a prize in a competition. In another instance, a positive experience of the students further imbibed an interest among other school students who did not participate but were excited to participate in competitions in the future owing to the learning experience shared by the student who took part. Interviews revealed how a cash prize of Rs. 1000-Rs.1200 positively reinforced and motivated other students.
- Roleplaying Game: Teachers found roleplaying activities and scenarios as an effective tool to garner interest among the students. One of the teachers simulated a typical bank visit experience involving conversation between multiple stakeholders. She pointed how the students were attentive and thoughtful while learning the concept of arithmetic.

c) Profiling students into personas

Students had different pace of learning and responded differently to the same interventions. For instance, some students struggled with braille reading owing to sensitive hands. These students would need more braille reading practice before they could engage in activities that would require proficiency in braille. Through inputs from teachers and resource persons, students with low braille literacy must be identified to facilitate tailored interventions.

Similarly, there are other axes of segmenting the students into groups to ensure that the activities conducted at ARC are catered towards their individualized needs. Some schools identify slow learners and arrange for extra classes to cater to their needs. Teachers mentioned how learning varied between slow and fast learners. While fast learners were quick to gauge the equipment and learn new concepts, slow learners needed repeated instructions and took considerable time to be acquainted with the materials. While conducting activities at ARC, it is important to identify and form student groups based on these learning characteristics. Along the same vein, there could be different provisions for low vision students. Unlike totally blind students, low vision students are able to use limited vision and have found apps such as YouTube helpful while learning about concepts. Thus, each activity to be conducted should identify modifications in the format that would be needed to align it to the needs of low vision students.

d) Important topics highlighted by the teachers

As shown in the findings, teachers identified few topics that were difficult to teach to the students. They requested for more TLMs to aid in teaching process. These are tabulated below:

Topics	**Remarks**
Seed germination process	Process and the different stages are a bit difficult to understand
Floating submarine model	Topic of floating, water pressure

Atom, molecule, compounds	Spatial understanding of the concepts
Speed, Velocity, Acceleration	How does velocity change in relation to speed? Relative velocity concepts are taught theoretically
Iron ball behaviour under the influence of heat	Dealing with heat is tricky as teachers expressed concerns
Optics: Reflection, shadow, refraction, dispersion, concave, convex lens	
Chord, Surface Area, Volume	
Measuring physical objects, scale of measurement	Comparing a ruler, students ask how long is the school? Such questions highlight that the concept of scale is unclear to the students
Electronic circuits	Students are scared and teachers need assistance in introducing to students
[Geography] Concept of rainfall, terrain and above sea level	Teachers expressed interest in using a TLM to teach the concept of sea level
[Geography] Latitude/Longitude	Teachers are using thread to teach the concept but not all the students correctly identify a latitude/longitude. Teachers expressed training in using geography related TLMs
[Geography] Earth Crust, Soil Layers	
Jyoti AI by Torchit	One of the schools highlighted how Jyothi AI offerings have been promising and they are training students to use it in their everyday lives
Wool, Silk fabric	
Digital Talking thermometer	
Titration color change indication software	
Digital weighing balance	
Electronics, digestive system, separation of liquids using filter paper, litmus paper	Agasthya Foundation TLMs that are helpful to the students
Chemical experiments such as mixing of hydrogen and oxygen to produce a pop sound	Teachers rely on assistance from sighted school for them to learn the concept using experiments involving chemistry/color change, etc.
Heart model	Ramnagar
3D model of globe, parts of body	Sidlaghatta
Talking LabQuest	As highlighted in prior literature

e) TLM revisions

In the visits to the schools, teachers revealed how some TLMs were rendered ineffective. The reported observations from the teachers are as follows:

1. “The tens concept that uses some sticks. Counting ten’s. Sticks get broken easily. Students are cutting the sticks. If you can provide something else then it would be good.”
2. Parts of animal model should be bigger in size
3. Geometry kit must have clear instructions with a demo video
4. Globe is not tactile enough. We cannot identify the direction of the continent. Matru Chhaya’s globe is better.

Teacher Training Sessions

As with the students, teachers also come from varied backgrounds. Teachers are not always assigned subjects based on their prior background. For instance, newly assigned STEM teachers and experienced STEM teachers. Some teachers are being assigned science and math owing to their communication skills or familiarity with the language but they do not have experience with teaching science. In some cases, the teachers keep rotating their subjects amongst them. In such cases, ARC could consider having a standardized scaffolding mechanism to ensure that the teachers could follow a basic guidelines/syllabus. This could ensure a minimum threshold for the quality of STEM education imparted to the students.

Some teachers are quite proficient in leveraging TLMs for teaching specific concepts. They implement their learnings to develop their own TLMs and they also make the most of the TLMs provided by VE. Such teachers could be identified as community leaders. This will help in further ideation/workshop when it comes to developing new TLMs. Networking among the teachers may help create a small micro-community of teachers with a vision to champion and lead the cause of innovating in STEM education through VE. ARC space could also be a testing ground for TLMs from various organizations such as Vividha Trust, Agasthya Foundation. Through iterative ideation of TLMs, motivated teachers could become “TLM ambassadors” championing the cause of promoting the use of appropriate TLMs in classroom learning ecosystem.

While most of the teachers thoroughly enjoyed Pragya Teacher training sessions, one of the teachers pointed that the concepts taught were similar to the previous edition of Pragya session. His experience of Pragya highlighted the need to segment the teachers based on strategic metrics such as TLM experience, motivation, etc. A beneficiary persona could help further elaborate on the type of teachers that would be benefitted. This may ensure targetted training sessions to assure most appropriate value addition for the teachers attending Pragya teacher training sessions.

Assistive Technology / Digital Literacy

Teachers reflected on their experience of learning computers and how that fundamentally remediated their learning experiences while growing up. Notably, one of the teachers pointed that she felt overwhelmed in college when she did not know computers. However, over a period of one year she took help from family and was able to prepare a power point presentation (PPT). At ARC where there are well equipped desktops, we could consider having PPT making activity with a basic introduction. This could be embedded in other activity such as Just A Minute and public speaking.

Secondly, AI has indeed made an indelible mark in the lives of PVI. Teachers have found immense value in applications that leverage generative AI to provide alt-texts. A tutorial on BeMyAI during the Pragya Teacher training session has left a deep imprint into the psyche of the teachers. They reported using it beyond the education context. More importantly, some of the teachers have also trained their students, equipping them with the necessary AI skills to use it for accessibility. Similarly, even the physical products such as glasses are now powered by AI. One of the notable examples that came up in the study was the use of Jyoti AI. Owing to its multilingual feature, it has received encouraging reviews from the teachers. While not specific to the context of education, teachers emphasized how they focused on imparting AI skills in everyday assistive technologies.

While on one hand, the prevalence of AI and its influence in assistive technologies has resulted in significant leap in attending to access needs, few critical gaps remain. One of the important aspects around assistive technologies is the awareness and training. In the schools that we visited, it was common to find advanced assistive technology such as Annie being unused by the school teachers owing to sophisticated configurations. The availability of Assistive technology did not result in access needs being met. Teachers were not trained in using the AT. As a shared space that hosts range of assistive technologies, ARC could conduct “Know Your AT” sessions wherein the teachers are debriefed about the utility and operation of assistive technologies. An immersive training session could be followed with follow up from resource persons associated with the schools to ensure that the ATs at the school are not underutilized.

Subodha – the learning management system has witnessed gradual uptake by the teachers. When asked about their Subodha use, teachers acknowledged that they found it helpful in referring to different teaching methodologies that could be employed. One of the teachers highlighted the need to develop a biweekly magazine through braille book, Subodha or WhatsApp group to augment Subodha and promote regular check-ins with regard to best practices for teaching specific concepts in their syllabus. With the growth of WhatsApp community of teachers, Vision Empower could consider having regular interactive messages to conduct surveys on instructional strategies and keep a check on the regular use of the TLMs.

Fostering an Ecosystem

Buddy program

As reflected by the teachers attending Pragya training sessions, they thoroughly enjoy connecting with other teachers. Beyond individual teachers, collaboration between different sighted schools have also found to be effective to reach last mile special school. Based on teacher motivation and effective use of TLMs, specific schools could be identified as nodal centres for disseminating experiential learning. Beyond the specific schools, other organizations such as Vividha Trust has had effective programs involving science experiments and teacher-student training. Such grassroots collaboration could also help scale up the initiative of an accessible lab.

Mobile Lab

While initiatives such as Agasthya Foundation have been conducting mobile science labs, they are not catered towards CVI. As we charter the path of scaling up accessible science lab, the concept of mobile lab could be further explored to ensure last mile connectivity for accessible learning experiences.

Local politics

Vision Empower's resource persons have been proactive in bringing structural changes at school level through collaboration with the school teachers. This has been mostly welcoming, however certain tensions emerged. In one of the visits to schools, it was revealed that the teachers did not use Hexis devices and a set of about 10+ Hexis devices were left unattended by the school teachers. Given the tremendous utility of Hexis, it was evident that it is being underutilized. The school coordinator had conversations with the school management officials which resulted in tensions between the school teachers and the school coordinator. This was identified by the school coordinator with an acknowledgement that not all the schools recognize the significance of the Hexis device. As a result of non-use, he had to take a difficult decision to channelize the Hexis device and allocate it for other schools. This had further implications with regard to the teachers communication with the school coordinator. These tensions are bound to arise owing to factors such as lack of motivation, and different priorities. This leads to a larger issue of addressing teacher motivation in using Vision Empower interventions such as STEM, CT Kits and ATs independently and willingly.

Building Futuristic STEM Aspirations

Practical are a barrier that prevent students to take up science beyond class 7. Beyond just experiments, ARC activities should tie the practical experiments to a larger movement of instilling interest in science in the higher education. As T1 mentioned that she was excited about science and was favorite subject while growing up but the very fact that there were no resources available, shaped her career aspirations. Now with ARC, VE must provide access

intimacy for the students. Specific example of scientists with visual impairment may help instill a sense of aspiration among students. This is important especially the school students may not have the wherewithal to learn science because of lack of resources. However, that should not deter them and prevent them from taking up science.

Currently, the career aspiration of the students and the topic of pride for the teachers is landing up a government job – due to job security. To facilitate diverse career opportunities, ARC programs could focus on interactions with popular figures who have excelled in STEM. Notably, alumni could have a huge role to play in instilling a sense of belongingness and attaining self-belief. Examples of alumni landing up in government jobs acts as a reference point and reinforces an ambition to work hard for government job. Similarly, successful STEM Alumni could be identified for invited talks for the students to interact and learn about career opportunities in STEM.

Personal reflections working at ARC

Over the course of these 11 months, I have had the opportunity to be a part of the ARC initiatives and witness some of the real life impact. I now share some of the learnings that have came along the way, by virtue of being a part of the ARC team.

Holistic understanding of the Accessibility ecosystem

During my tenure, I got the opportunity to attend conferences that covered various aspects of accessibility. A notable experience in this regard is my participation in the CTDP conference held at IIM Ahmedabad. The conference presentations brought about interesting perspectives around disability and accessibility in public domain. At the product exhibit, the Touchetech Geometry Kit was demonstrated to attendees. Other demonstrations spanned people from startups to even person affiliated with government. These demonstrations and the ensuing conversations opened-up conversations about the adoption of Assistive Technologies beyond mere technological innovation. The practical challenges of adoption and programmatic interventions of the government were also widely discussed. Having read academic papers, the perception of “lack of infrastructure”, “low-resource settings” often comes up every so frequently. But when I got to hear from Dr. Rajesh Aggarwal from the Department of Empowerment of People with Disabilities, and it was very enlightening to hear government perspective on the pertinent issues which they have been working on. What I saw at CTDP was a genuine intent to work towards addressing pressing challenges in the domain of disability broadly. This was further echoed in my discussions in the run up to the NCPEDP. The multi-stakeholder discussion was aimed to serve as a common platform for all the stakeholders involved in the assistive technologies.

The complexities around the AT ecosystem was further highlighted in the ARC inauguration where there was an engaging panel discussion. Collectively, all these experiences introduced me to engage with the domain at a deeper level.

Organizations harnessing synergies

Throughout the tenure, I saw multiple visits by people working on adjacent challenges. The exchange of knowledge and expertise across different organizations, I feel is a real strength while innovating and designing programs. The discussions were focused on exploring common objectives that a collaborative endeavor could address. In my fieldwork, teachers often mentioned Vividha Trust program, particularly for their Curious Minds event. It was great to know how Vision Empower collaborated with Vividha Trust for their Curious Minds event for the 2024 edition. In my discussions with Prof. Saswathi at APU, I saw how there was genuine interest in pedagogical innovation. As different organizations came together at ARC, I felt that there was a common understanding and convergence to further leverage domain expertise.

Token participation to true participatory action research

One of the biggest learning for me was to understand and appreciate the difference between token participation of people with disabilities and long-term participatory action research. I got to know how CSR initiatives of companies such as Bosch and Microsoft go beyond mere funding to proactive engagement through volunteering.

Collaboration with CAGS Researchers

As a part of Teaching Assistantship for the course on Introduction to Accessibility in the Global South, I got an opportunity to be closely involved in syllabus design, teaching, evaluations. As an aspiring academic, I feel this was a very important experience to gain. The flow of the classes, the kind of pre-class readings, grading were some of the aspects collaboratively done with other CAGS researchers. This allowed avenue for further discussing theoretical frameworks and knowing more about fundamental academic work that is at the core of disability studies and design. The guest speakers provided more nuance to my evolving understanding about meaningful engagement with people with disabilities.

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