INTRODUCTION

One of the several provisions enshrined in the Constitution of India to promote equity and inclusion in society, defines education as a state subject, and a fundamental right for all its citizens. Article 21A of the Constitution mandates free and compulsory education for all children between the age of six to fourteen years. India passed the Right to Education (RTE) Bill in August 2009, which laid down special provisions to make education accessible to all children, especially those belonging to marginalised and underserved communities, ensure their all-round development, and develop the next generation of leaders. The RTE Act, 2019 was enforced with the principal aim to redress the urban-rural imbalance and bring down the barriers to accessing infrastructure, resources, and communication that have a bearing on education. The Act also aims to empower the rural youth to realise their full potential and create innovative context-appropriate programmes and pedagogies for their communities. In reality, however, there are several impending challenges that include the prevalent gender divide (“Bridging the Gender…”, 2020), disproportionate socio-economic positions, unequal access to healthcare, technology and public transportation, lack of connectivity, a top-down approach to policy-making, etc., all of which act as impediments to the transformative vision of the Indian education system.

To build and strengthen the knowledge economy of the nation, the Government and its allied partners in civil society organisations (CSOs) and tech industry have formed collaborative partnerships to ensure digital literacy for all its citizens, which would in turn guarantee that the government services, policies, and schemes become accessible to all citizens equally and seamlessly. The CSOs have played a significant role in regional, national, and international platforms to co-construct various digital models of inclusive education and knowledge systems. The Digital Empowerment Foundation (DEF) is aligned with the national mandate of democratising technological innovation and creating a literate and information-rich knowledge society. It has joined hands with the Government to bridge the digital divide¹, digitally empower local communities, equalise the access to technology for rural youth, and overcome systemic roadblocks to the use of technology in enhancing their learning outcomes. Concerted efforts have been taken in the past decade to redress and bolster the digital ecosystem, to ensure a robust education sector that would bridge the gap between the reality and the vision of India’s education policy.

One of the main organisational objectives and activities of DEF has been to explore the critical linkages between education and digital empowerment, with efforts directed towards enabling youth to access education, health, skill, and livelihood opportunities through digital literacy and digital tools. To achieve the same, the organisation has focussed on making technology easily accessible to youth, especially to empower people in rural India, girls, women, persons with disabilities, and other underserved populations to ensure a meaningful life with human dignity. Taking this vision forward, DEF created START², an ongoing 45-hour digital learning curriculum, and a Media and Information Literacy (MIL) toolkit, with an aim to impart digital literacy to the first-generation internet users among marginalised communities including tribal and other marginalized communities. The National Digital Literacy Mission (NDLM)³, which has been adopted by GOI as a scheme to enhance digitally inclusive societies, reach out to all gram panchayats, and ensure that every single household in India has at least one digitally literate person, was at the outset launched by DEF, along with Nasscom Foundation and Intel in 2014.

Gyanpedia⁴, an online multilingual database of digital content, curated by students and teachers in rural India, is a grassroots initiative launched by DEF with the help of Media Lab Asia. The purpose of generating content on this platform has been to facilitate the exchange of communication, information, and knowledge between local

---

² https://youtu.be/cThMPvYNmo8
³ https://nielit.gov.in/ajmer/content/national-digital-literacy-mission
⁴ http://www.gyanpedia.in/
communities, Government, CSOs and tech industry. Another initiative by the name, District Public Library has been embarked on by DEF, which led to the Indian Public Library Movement in Telangana, among many other states. The efforts have been directed towards equipping and strengthening public libraries in ten districts across Telangana, using advanced digital resources, including the Information and Communication Technology (ICT) tools. In 2014, DEF implemented Helping Women Go Online, which provided the necessary infrastructure and training to women to operate computers and use internet services. DEF also took the initiative of Integrated Technology in Education (ITE) in North-East India, with an aim to bridge the digital divide vis-à-vis the rest of India. ITE departs from teacher-directed learning to student-centred learning, and equips young minds with critical thinking and reasoning skills.

Since 2015, DEF has been an implementation partner to Internet Saathi. Through this initiative, DEF has reached out to about five million young girls and women in Madhya Pradesh, West Bengal, Punjab and Bihar, with the assistance of approximately a digital cadre of 10,000 Internet Saathis (each Internet Saathi or friend was responsible for training at least 500-600 adolescent and young girls on mobile and internet). In the same year, DEF also started the initiative called Raising Standards of Education and Going Digital (RAISED), designed to use modern teaching methods such as e-learning, etc., and ICT tools to adopt an IT-based education. One of the main objectives of the RAISED programme has been to ensure compliance with the norms laid out in Right to Education Act (RTE) and GOI’s flagship programme, Sarva Shiksha Abhiyan (SSA).

In 2016, DEF started a flagship programme titled, English and Digital for Girls’ Education (EDGE) in partnership with the British Council, with an aim to develop digital literacy, language proficiency, and confidence among girls from marginalised communities. Continuing the digital push among the youth and unconnected, DEF also joined hands with Facebook to bridge the gender divide that is widespread in the digital ecosystem, and facilitates education and career opportunities for women in rural parts of the country, who are deprived of digital access and education. This programme includes mentorship and digital training by urban-based women role models using the social media ecosystem, and is aided by DEF’s locally pre-established Community Information Resource Centres (CIRCS). The program was named GOAL (Going Online As Leaders), which became popular for its profound impact. The Ministry of Tribal Affairs adopted the GOAL program into a national scheme and ran it through a PMU (Program Management Unit), supported by Facebook.

With the said vision of taking technology-led innovation to underserved regions of India, DEF also extended its support to STEM education, a school-based programme that works towards transitioning from blackboards to design-thinking and scientific temper, involving electronic gadgets, and from traditional methods of teaching to activity-based learning, especially for girls in rural India. One of the main objectives of DEF’s STEM project has been to break gender barriers, and pave a path for young girls to step into the tech world. A report released by DEF, titled “STEM for Girls”, details the project pursued by DEF in association with various government schools in Telangana and Assam. This report is a joint work by DEF and the Quest Alliance, which also supported the Sterling File Gateway (SFG) programme, with the support of IBM. Being an integral part of a school-based programme, STEM for Girls has inculcated life skills, career, gender, digital literacy and coding skills among girls pursuing secondary education, with the aim to prepare them for the real world. This learning enabled DEF to

---

6 http://www.hwgo.com/
7 https://www.defindia.org/bringing-technology-in-mainstream-education/
8 https://indianexpress.com/article/technology/tech-news-technology/rural-women-transforming-communities-google-internet-saathi-4566849/
9 https://www.defindia.org/education-empowerment-2/#RAISED
10 https://www.india.gov.in/official-website-sarva-shiksha-abhiyan-0
13 https://www.defindia.org/circ/
14 https://goal.defindia.org/
15 https://goal.tribal.gov.in/
17 https://www.defindia.org/breaking-the-barrier/
integrate the STEM project with several other projects and programmes, including Smartpur. Under the Smartpur model run in Uttar Pradesh’s Ghazipur, an entrepreneurship-based model created to make a digital village ecosystem in rural India, DEF has organised STEM training for students. In addition to the efforts of DEF in collaboration with tech industry and other members of civil society, the Government has also directed its efforts towards integrating STEM curriculum with the existing model of Indian education system.

TINKERING LABS: REIMAGINING EDUCATION AND DIGITAL ECOSYSTEM

When the Covid-19 pandemic hit India, there was a sudden need and demand for electronic gadgets to access the digital portals, which still remains unattainable for most adolescents and youth population in today’s India, given the socio-economic disparities in Indian society (Pokhrel & Chhetri 2021). In the pre-pandemic times, the concept of e-learning and online education was limited to availing distance education under open universities. Whereas in the post-pandemic world, online teaching and learning (Mishra, Gupta & Shree 2020) have become massive challenges to deal with, due to the scale of demand of the resources, both at the technological and social levels. A drastic pedagogical shift from classroom learning to online learning during the Covid-19 pandemic ensued, which required curriculum restructuring, appropriate learning/teaching methods and investment in digital infrastructure, to meet the demands of a transformed e-learning-based education system (Lederman, 2020). In this continually shifting landscape of the pandemic, the Government implemented many programmes to bolster the online education system.

The Digital Education Division of Department of School Education & Literacy, Ministry of Human Resource Development, GOI, released a report in June, 2020 titled, “India Report - Digital Education” detailing the several remote learning initiatives taken across the country (“Remote Learning Initiatives…” 2020). The Study Webs of Active-Learning for Young Aspiring Minds (SWAYAM)22, SWAYAM PRABHA, Annual Refresher Programme in Teaching (ARPIT), Pariksha pe Charcha, DIKSHA and NISTHA portals under PM e-Vidya23, Rashtriya Aavishkar Aahhiyan, e-PG Pathshala, etc. are few among several programmes launched by the Ministry of Education to strengthen the education system.

Two years after the emergence of pandemic, it has increasingly become important to also formulate new pedagogical tools and methods that would facilitate critical thinking, learning outcomes and problem-solving innovative mindset for students, especially to empower those who have lesser or no access to infrastructure and resources. The persistent changes in the Indian education system have caused a major paradigm shift in pedagogy, from the traditional teacher/instructor-led schooling to a more critical student-centred learning model24. The new model aims to integrate the model of STEM education with school education, whereby a bottom-up approach and participatory-based learning techniques are adopted that would allow students to engage in hands-on activities, evaluate, learn and apply their knowledge in the real world in their own stride.

Prior to the pandemic, the Government introduced the concept of a tinkering lab, with a similar vision of fostering a culture of curiosity, creativity, and imagination among school-going students. NITI Aayog’s Atal Innovation Mission (AIM), a flagship initiative of the Government, launched the Atal Tinkering Lab (ATL) programme in 2016, whereby tinkering labs were set up in many schools across the country. One of the main objectives of this programme has been to set up laboratories where students can innovate and create ideas, experiment and learn in an environment, which is stimulating and flexible at the same time. The labs are set up for students pursuing secondary and higher secondary education, with the aim to facilitate self-learning about the concepts of STEM (Science Technology Engineering Mathematics). The Government has equipped these laboratories with workspaces, meeting rooms, video conferencing facilities, the latest emerging tools and technologies and most

19 https://smartpur.in/the-project/
20 https://www.defindia.org/learning-made-easy-through-stem/
22 https://swayam.gov.in/
importantly, the ‘do it yourself’ kits, which include electronics, computers, Internet of Things (IoT), 3D printing, robotics, etc.\(^{26}\)

The Covid-19 pandemic and the following national lockdown set new challenges for the ATL programme. Almost overnight, all educational institutions including schools, colleges, and universities were forced to an unprecedented and mandatory transition to remote learning models. It became a huge challenge for educational institutions in India to adapt and embrace the digital platform, and the subsequent acceleration of digitalization after the pandemic (Jain, 2020). As a result, the NITI Aayog’s AIM started a campaign called, “Tinker from Home”\(^{27}\) in partnership with the education sector and tech industry. The ATL programme switched to the online medium and held multiple workshops, meetings and training programmes to ease the transition process for students. Besides, a teacher training programme called “Unbox Tinkering”, had also been launched for capacity building of teachers to master the tools pertaining to the digital interface\(^{28}\).

With uncertainty about the pandemic looming over for India, the educational institutions are crawling back to a new form of normalcy, whereby the concept of hybrid learning\(^{29}\) has gained prominence over a singular method of learning. This new model involves classroom interactions, both in online and offline settings thus providing secure and flexible opportunities for hybrid learning. While the Government is spearheading the efforts to modernise the Indian education system, the digital divide\(^{30}\) and the urban-rural imbalance continues to pose challenges in imparting equitable education to all citizens. A report\(^{31}\) released by the Ministry of Education, titled “Initiatives by the school education sector in 2020-21 for continuing teaching and learning” showed that more than 2.9 crore children in India do not have access to digital devices. Moreover, the impact of the pandemic revealed the pervasive nature of inequalities and socioeconomic disparities in access to education, healthcare, and finance, which resulted in a steep rise in school dropouts\(^{32}\) across the country. The ATL Labs are yet to reach out to several thousands of schools in rural India.

UNESCO and UNICEF released a joint report (“India Case Study…”, 2021), which documents the impact of Covid-19 pandemic on the Indian education system, and builds strategic responses and solutions to the abrupt setbacks caused at social, spatial, and institutional levels. Most importantly, the report reminds us that many children were not enrolled in schools or part of any learning programmes before the emergence of the pandemic crisis. To address these impending serious challenges of digital divide, and to ensure equitable and critical education, DEF has resolved to facilitate the efforts of the Government, by working towards developing an accessible learning model, which in contrast to the existing model, takes the technology-led innovation to rural India and empowers the rural youth for life skills development and livelihood security.

THE MAKERSPACE: TOWARDS AN ACCESSIBLE LEARNING MODEL

DEF’s Equally Able Academy of Digital Empowerment\(^{33}\) envisions a world without a digital divide that disempowers people, especially those with social and physical disabilities. To create sustainable educational opportunities, DEF, in partnership with Pyar Trust and Equally Able Foundation\(^{34}\) created a multi-dimensional toolkit to tackle the digital divide and the lack of a critical and real-time activity-based approach to education. Departing from the top-down approach to developing problem-solving mechanisms, DEF works towards finding inclusive and innovative solutions, which are created through the lens of local communities, and that incorporates their voices and sensibilities. The Academy launched an initiative called Make2 or Makerspace for Knowledge,

\(^{26}\) https://aim.gov.in/overview.php  
^{27} https://www.niti.gov.in/how-atls-are-boosting-skills-indian-youth  
^{32} https://scroll.in/article/1013312/the-children-who-quietly-dropped-out-of-school  
^{34} https://www.defindia.org/fostering-innovative-learning/
**Education & Exploration**, which functions on six cardinal principles of the technology-led education system. The cardinal principles are:

1. Inclusive: designed for and by communities with physical and social disabilities to include the marginalised adolescents and adults across the country.

2. Innovative: encourage frugal engineering, inculcate skills of creativity and promote multidisciplinary thinking to solve real-world problems.

3. Educational: facilitate open learning and teaching; focused on student-centric inquiry.

4. Functional: creating spaces and processes that are easily accessible, practical and mindful.

5. Sustainable: constructed using environmentally responsible and energy-efficient design and architecture.

6. Resourceful: equipped with physical tools, modern technology, and digital infrastructure.

The Makerspace project aims to help communities broaden experiential learning at the grassroots level and enhance rural innovations through exploring interests in science, technology, and creative arts. Departing from the concept of STEM education, DEF recognizes the role of arts in STEM education as an important step towards evoking a creative level of communication about the world. It thus facilitates the learning about the concepts and application of STEAM (Science Technology Engineering Arts Mathematics). The curriculum content created in Makerspace is designed to inculcate curiosity, analytical, design computing, mathematical, team-working skills, and leverage a design-thinking approach for identifying real-time community problems, and creating tangible contributions to rural development. By taking a bottom-up approach to problem-solving and nurturing a sense of inquiry, the local communities are encouraged to pursue higher studies and careers in the tech industry, aligned with the demands of the 21st century.

The project, on one hand, collaborates with schools, especially those without the ATL programme, and on the other, targets and mobilises communities through its centres, which have been excluded from mainstream society due to their economic, social, physical, cultural, political and geographical conditions. The target beneficiaries for this project include persons with disabilities, girls, women, sexual minorities, religious minorities, Dalit and Adivasi communities, denotified tribes, etc. It focuses on children enrolled in 6th through 11th grade, and covers geographies across India, especially those from unconnected and remote districts and regions in India. The Makerspace is at present operational across eight states in the country, including Uttar Pradesh, Haryana, Rajasthan, Andhra Pradesh, Telangana, Karnataka, Pondicherry and Delhi. The programme provides learners with two kits: Level 1 and Level 2. While the Level 1 kit is a three-month programme that facilitates the hands-on use of electrical and mechanical-based tools, the Level 2 kit is a two-month programme, whereby learners are provided with electronics and robotics-based equipment, 3D printers and computers. The Makerspace provides these toolkits to the schools that are not covered under AIM, and facilitates their STEAM learning. The programme additionally organises workshops and career counselling sessions to prepare youth for professional careers. So far, the programme has reached out to learners in eight states across the country, the details of which are listed in the following table nos. 1 and 2:

<table>
<thead>
<tr>
<th>Makerspace programme</th>
<th>No. of learners enrolled across 8 States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learners pursuing STEAM education</td>
<td>4620</td>
</tr>
<tr>
<td>Attended Career Counselling sessions</td>
<td>4200</td>
</tr>
<tr>
<td>Attended STEAM workshops</td>
<td>4320</td>
</tr>
<tr>
<td>Total number of learners involved in Makerspace programme</td>
<td>13140</td>
</tr>
</tbody>
</table>

**Table No. 1 Number of learners associated with Makerspace programme**

<table>
<thead>
<tr>
<th>Target populations</th>
<th>No. of learners enrolled across 8 states</th>
</tr>
</thead>
<tbody>
<tr>
<td>Girls</td>
<td>5256</td>
</tr>
<tr>
<td>Boys</td>
<td>7800</td>
</tr>
<tr>
<td>Persons with Disabilities (PWD)</td>
<td>84</td>
</tr>
</tbody>
</table>

**Table No. 2 Number of target beneficiaries of the Makerspace programme**

The Makerspace is an attempt to democratise technological innovation by providing space and tools to rural youth to experiment and learn. Lack of infrastructure and access to educational tools inhibits the youth in rural India.

---

35 [https://www.defindia.org/schools-need-space-for-digital-makers/]
from realising their full potential and creating innovative context-appropriate solutions for their communities. This initiative is based on the idea of ‘innovate, invent, peer-learn, co-create’. In these spaces, the students and adolescents are exposed to a hands-on, STEAM-based approach and creative ways of learning to encourage them to design, build, experiment, and innovate while they engage in science, technology, art, engineering and mathematics. Therefore, it facilitates a shift from “learning to know” to “learning to do” and “learning to work together”. It also provides an unstructured learning space supported by the machine and digital tools of learning that allows children and youth to take ownership of their learning. Further, the Makerspace initiative designs the physical spaces in a manner that fosters self-reflection and immersive learning. To teach digital literacy, DEF employs a variety of formats such as online learning and bot-based learning. This programme has a special focus on girls and persons with disabilities, and is aimed at addressing their disproportionately low representation in STEAM education. It is envisaged that this STEAM learning programme will support them in accessing livelihood, education, and quality day-to-day life. The programme is also designed to help them to think critically, and will enable them to make tools that are beneficial to persons with disabilities.

The Makerspace consists of a digital centre equipped with STEAM learning and digital skilling tools. Understanding the importance of confidence-building, these spaces also conduct mental health sessions and motivational sessions. The Makerspace is a model of self-learning based on the idea of ‘invent to learn’, wherein the students are exposed to hands-on and creative ways of learning to encourage them to design, build, experiment, and invent while they engage in science, arts, engineering and tinkering. Design-thinking is a mindset and a structured approach to developing and generating ideas. Educators have used it as a tool to inculcate a sense of optimism to act when faced with challenges and participate in building a better future. The Makerspace has five phases of the design process:

1. Discovery: I have a challenge. How do I approach it?
2. Interpretation: I learned something. How do I interpret it?
3. Ideation: I see an opportunity. What do I create?
4. Experimentation: I have an idea. How do I build it?
5. Evolution: I tried something. How do I evolve it?

The primary aim of the curriculum is to foster curiosity, learning and experimentation, which will lead to a knowledge-based learning rather than education-based learning, eventually creating a pool of makers. The secondary aim is to develop an understanding and identify various global issues and design creative solutions to tackle the same. This co-learning and co-creating space imparts 21st century skills that can add real and applicable value to our rapidly changing world. The lab creates a conducive space for youth to transform their ideas into reality, or be trained for future jobs in the world. Analysing big data, understanding artificial intelligence and innovation with 3D printers, robotics and web or mobile-based applications are the main focus of Makerspace’s efforts. The Makerspace curriculum is based on self-learning modules with the support of the following technologies - 1. Fabrication; 2. Physical Computing; and 3. Computer Programming. Along with the knowledge-based learning, the programme also focuses on soft skills that include - 1. Meaningful Collaborators; 2. Creativity and Innovation; 3. Knowledge Building; 4. Enquiry and Problem Solving; and 5. Critical Thinking. The projects and prototypes are created to solve problems across various fields including society, governance, democracy, food and agriculture, health and education, language, art, culture, heritage, science, sports, water, energy, environment, economy and gender. The learners have access to several offline and online educational resources to facilitate research and additional learning through the channels, including the creative commons resources, subscriptions to international publications and online libraries, guest lectures and workshops, learning journeys and field visits. The Makerspace works towards creating patents on ideas and products and at the same time, gives open access to its knowledge, processes, and the space.

**CONCLUSION**

There is a lot of work at hand to be done in order to ensure the digital and social inclusion of the underserved populations in India. Several initiatives and policies have been introduced by Government of India (GOI) and its allied partners in civil society and tech industry, with the aim to democratise technological innovation and provide equal opportunities for youth to attain education. One of the key means to achieve the same has been through enhanced use of digital technology in education (“The State of the World’s Children 2017...”, 2017), and involvement of community and private sector in schools and colleges across the country. The latest National Education Policy (NEP) implemented in July 2020 has also emphasised the need for introducing digital learning as an alternative to the mainstream model of formal education, to prepare the youth to excel and sustain in the new digital era. India has also embraced the swiftly growing educational technology industry, popularly known
as EdTech, wherein new systems of learning equipped with adequate digital tools and smart technologies such as Artificial Intelligence, Machine Learning, etc. have emerged. With the advent of the Covid-19 pandemic, the education sector has departed from the traditional classroom learning model, and adopted a pedagogical framework, whereby the curriculum content and classroom learning methods are prepared for students’ interests and needs. To achieve the same, a student-centred pedagogical framework of STEAM (Science Technology Engineering Arts Mathematics) has emerged lately, which inculcates critical thinking, problem-solving skills, and prepares students to become innovators. The Makerspace is a step towards the vision of strengthening the education system in India. The programme offers an accessible model of self-learning, whereby students are referred to as learners, and teachers as trainers or facilitators. The main objective of the programme is to facilitate support to the underserved schools, especially in rural India, and contribute to the overall growth and development of rural economy. Owing to the urgent need for an inclusive and accessible model of education and digital empowerment, the programme aims to reach out to learners pan India, and as many schools as possible in near future.

References


36 https://stemlearning.in/csr-solutions/tinkering-lab/