The “Every Child A Scientist” program: using digital technologies to enhance science learning among middle grade students from corporation schools in Chennai

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Abstract The “Every Child A Scientist” (ECAS) program, since its inception in 2002, has emphasized the importance of experiential and activity based learning to supplement standard “chalk and talk” learning. In a modified version of this program (2021–22), 153 middle school students from two corporation schools of Chennai participated in a two-week science learning sessions using digital e-learning modules. The present study summarises the outcomes of this program. The customised course content developed based on the state school curriculum, delivered using digital smart boards, with audio-visual learning, hands on practical sessions, provided easy grasp of scientific concepts. Integration of practical laboratory based sessions bridged the gap between theory and practice. Simplifying science learning using digital tools has the potential to enhance school academic performance. Students could consciously relate scientific concepts to events in their day-to-day life. Bilingual teaching contributed to easy assimilation and understanding of science concepts. An enabling academic environment with approachable educators is crucial to science learning. Access to internet and desktop systems, awareness of internet based learning resources as secondary sources of learning facilitated and fostered self-learning. Providing nutri-dense meals in schools for overall cognitive development, better learning and physical growth will also ease parental pressures. Thus, technology and science based methods will provide solutions to big challenges in the future. In this context, providing quality science education using digital tools can help integrate socio-economically marginalised students into the main stream.

Keywords Smart classrooms · Corporation schools · Digital infrastructure · Internet · e-modules · Nutri-dense meals

1 Background

The global education development agenda encapsulated by Sustainable Development Goal 4 (SDG4, United Nations) seeks to “ensure inclusive and equitable quality education and promote lifelong learning opportunities for all” by 2030 [1]. The Education policy in India aims to making “India a global knowledge superpower”. This ambitious goal requires radical changes in education including science learning by providing high-quality education to all. Article 21-A in the Indian Constitution and the Right of Children to Free and Compulsory Education (RTE) mandates by law that every child has a right to full time elementary education in a formal school which fulfils essential norms and standards [2]. Research shows that inequities in access, resources and outcomes (due to geographical or economic disadvantages), deeply impact learning, knowledge and critical thinking in children that can have negative consequences in adult life.

As per the Unified District Information for Education (UDISE) records, of 15.1 lakh schools in India, 10.32 lakh are government schools [3]. Government schools cater to the educational requirements of children from diverse backgrounds. These schools also host children of migrant
families and other economically disadvantaged sections of society. Some children are first generation learners, who, in addition to school work, contribute to household chores. In a large number of cases, their parents do not have the ability to support them with their learning and homework. High student to teacher ratios in government schools, time constraints due to non-academic duties and resource constraints are limitations to teaching and policy implementation. While there has been an increase in enrolment in government schools between 2018–2021 [4], the Covid-19 pandemic has exacerbated learning difficulties, driving parents from low income earning families to seek tuition based learning [4] and also exposed a digital divide between the economically privileged and the under-privileged sections of society. On the flip side, it has also shown, that with adequate online resources and access to digital tools, it is possible to make lessons available to a wider audience with flexibility in time scheduling of learning.

In the years to come, technology and science based methods will provide solutions to big challenges that require collaborative and creative ‘working together’ across trans-disciplinary silos. Digital technologies for Science, Technology, Engineering and Mathematics (STEM) learning have the power to provide access to a vast untapped store of knowledge for teachers, parents and children, with models of real interaction to enhance learning due to crucial visual and auditory inputs\(^5\). These technologies can also be harnessed to connect all stakeholders to a wider educational community, provide access to learning/teaching resources online to encourage collaboration and learning across space and time divisions. They can also provide individual learning opportunities that can be based on any previous level of knowledge or experience [5]. At the national level also, there is an increasing push to integrate schools in science learning programs that involve innovation and generation of creative ideas that can contribute to societal change (MANAK; https://www.inspireawards-dst.gov.in/userp/award.aspx).

The Government of Tamil Nadu (TN) has initiated Informa-
tive ideas that can contribute to societal change (MANAK; https://www.inspireawards-dst.gov.in/userp/award.aspx). The ECAS program, since its inception in 2002, has emphasized the importance of experiential and activity based learning to supplement standard “chalk and talk” learning. Experiential learning has been recognized as a means to attract and retain students in STEM and present STEM as an opportunity to create knowledge through the experience gained [8]. In a modified version of the ECAS program, middle school children from two corporation schools of Chennai participated in fifteen-day science learning sessions using smart boards, hands on practical sessions, access to internet and desktop systems on subject modules developed based on the state school curriculum. In addition, teaching modules on sustainability science that forms part of M. S. Swaminathan Research Foundation (MSSRF)’s core research themes, were also taught. Preliminary surveys suggested that most children attended school without eating or only had beverages or gruel (kanji). Therefore, during the program, health drinks and nutritious meals were provided to reinforce the importance of nutrition and health and its impact on cognition and learning. The ECAS program envisages shorter training periods to reach out to a larger student base, and to foster a critical and scientific way of thinking and innovation in schools to build a vibrant knowledge society. The learnings and outcomes of this program over a one-year period are presented here.

2 Methodology

2.1 Course structure

Middle school science textbooks (grades 6–8) published by the Department of School Education (Tamil Nadu State Government) were downloaded (https://textbookcorp.tn.gov.in/textbook1.php) and, based on the prescribed curriculum, teaching content sorted as: subject (chemistry, physics and biology) as well as theme (grouping course content across three grades) wise. In addition, based on MSSRF’s core research areas, additional teaching modules were developed (sustainability science, agriculture, plant and microbial biodiversity, nutrition and health). The teaching schedule included theory as well as practical/demonstrations. For each subject and theme, theory content was developed in the form of slides (Powerpoint)\(^5\) with embedded text, pictures and videos that were presented using an interactive smart board (with internet access). Internet acess could also be used to access demand based information in real time as the lesson progressed. Course content was carefully edited to include information relevant to the age group targeted and also in line with the school curriculum. Overall, about 30 modules were developed.

2.2 Coordination with the city education department

The Chennai city education department was contacted to enlist schools from corporation zones 8, 9, 10 and 13 (within a 2 km radius of MSSRF). All necessary permissions in this regard, both from the corporation education department, as
well as the school were obtained. The data presented in this study involves 135 middle grade students from two schools. Overall, 153 students attended the program in 5 batches of 30 students each. Transportation for students was arranged and accompanying attendants ensured safety of the students. In view of the ongoing pandemic, protocols instituted by the local government were followed to ensure Covid-19 appropriate behaviour.

2.3 Teaching and assessment

Teaching modules were conducted for fifteen days for each batch of students, with three hours of instruction per day (three hour theory sessions) and two hours practical demonstrations. Preliminary data and a brief socio-economic profile of the students were collected. Assessment of prior knowledge was also carried out using a multiple choice question format at the start of the program and concept uptake was also assessed at the end of the fifteen day course. A conscious effort was made to teach in bilingual mode (English and local language, Tamil) for a better grasp of content. The core curriculum content was developed based on the prescribed state school text books. It was complemented with audio-visual aids (videos, cartoons etc., and other online resources) to reinforce learning concepts.

2.4 Digital classrooms

The digital class room included an interactive smart board (Senses Lite Interactive Intelligent panel, Resolute Electronics, India) and personalised desk top system. The smart board had the following features: wireless screen sharing, a web browser, cloud access based teaching. screen recording, multi-language, text and shape recognition and voice

Fig. 1  Feedback on the course content of the ECAS program from participating middle grade students
recognition, class room scheduler, graph line screen and auto email. The smart board supported Microsoft PowerPoint (ppt), pictures, videos, and text writing on the same page. The modules were developed in consultation with subject experts. The final module was developed by integrating ppt slides, text, videos and pictures into a format that was compatible with the smart board system to make lectures easier, engaging, and more interactive.

2.5 Integrating practical lab-based learning

In the practical sessions, students were provided access to laboratory facilities to facilitate practical learning in subject areas relevant to theory modules. This was complemented with library and kitchen garden visits and lecture-demonstrations by researchers at MSSRF. Students were also encouraged to develop and present models or demonstrations based on content taught and to make presentations to instil confidence and encourage public speaking. Students were also provided individual desktop systems, guided to create personal email identifiers and also encouraged to search for information using internet tools.

3 Results and discussion

Students’ (67 girls and 68 boys) academic progress and program outcomes during the academic year 2021-2022 were assessed using a questionnaire. It included feedback on (i) course content (eight questions), (ii) subject relevance (four questions), (iii) teaching methodology (six questions) and (iv) utility of digital tools and advantage (six questions). The response of the students is analysed and discussed below.

3.1 Feedback on the course content of the ECAS program

All the students (100%) found that the ECAS program contributed to their overall academic progress and more than 96% said that both -theory and practical sessions were easy to follow and assimilate. 97% of the students found that the customised lecture demonstrations delivered during the two week program using digital smart pedagogic methods were easy to grasp (Fig. 1A). The students could be categorised into three approximately equal groups based on the level of prior knowledge (20–50%; 50–75% and 75–100%). More than half the students felt that at least 50% of the course content was relevant to their learning needs (Fig. 1B). 83 students indicated an increased understanding of course content related to physics and chemistry (Fig. 1C). An overwhelming majority (111) preferred video based learning and found practical laboratory sessions interesting (Fig. 1D). Visual learning aids provide more coherence of STEM concepts that have benefits beyond mere verbal explanation [9]. Further, when used creatively, they can enhance experiential learning.

![Fig. 2 Feedback on interest in science and scientific concepts after attending the ECAS program](image)

**Fig. 2** Feedback on interest in science and scientific concepts after attending the ECAS program

I: Did your interest in science increase after attending this program?
II: Developing models using scientific concepts taught.
III: Attempting new experiments
IV: Scientific rationalization and interpretation of day-to-day events.
3.2 Increased curiosity towards science

94% of the students indicated an increased interest in learning science, while 83% of them developed models by using scientific concepts taught in the classroom (electric circuits; baking soda and vinegar volcano; invisible ink using turmeric, acid and base etc.). 86% of the students could consciously apply the scientific concepts that were taught and confidently attempted new experiments that related to their daily activities on their own (crystallization of sugar,

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**Fig. 3** Feedback on pedagogic methods and course content of the ECAS program
composting, biogas production; isolating bacterial flora on fingers using agar plates, chlorophyll extraction and chromatography). For this, they utilized information from the practical videos shown in the class as well as accessed information from social media sites in the internet. Finally, 90% of them could scientifically connect events in their day-to-day life (working of a lift; energy inter-conversion in fan; production, presence of starch in amyloplasts for gravity orientation of roots; microbes and their role in composting, segregation of degradable and non-degradable waste) to the concepts taught and demonstrated in the program (Fig. 2).

3.3 Feedback on pedagogic methods and course content of the ECAS program

84% of the students felt that they were at an advantage relative to their school peers after attending this program. 92% felt that the pedagogic methods used made science learning easier and interesting. 96% said that they would recommend attending the two week training program to their peers (Fig. 3A). An overwhelming number of students (97%) preferred bilingual teaching (English and Tamil) for easy assimilation and understanding of science concepts and 98% found the teacher approachable and the training program to be of competent standard (Fig. 3B–3D). Students in many classrooms in which STEM is taught in India are at least bilingual and often multilingual. Research has established that mother tongue based multilingual education is vital to develop and enhance creativity and critical thinking skills in students [10]. This is especially crucial for a critical understanding of STEM concepts. Further, stark differences have been noted in reading and academic performance of students receiving bilingual education relative to those receiving instruction in a standard single (often national) language [10].

3.4 Digital tools for science learning

94% of the students were confident in accessing the internet for scientific information (eg., using Google Lens to identify plant species, creating G-mail account etc.) and handling desktop systems {98%; key board functions, copy/paste, and using Microsoft word, using Google translator to understand Wiki data in Tamil, using Internet based Apps (Arduino & Pulse Sensor) to monitor heart functions based on sensors connected to the desktop systems)} (Fig. 4A). 95% of the students were exposed to new scientific concepts (DNA
extraction; Polymerase Chain Reaction technique; agarose gel electrophoresis; bacterial isolation; sensors; thermal conductivity of different materials; use of pH strips and pH meter, use of Stethoscope and Sphygmomanometer; test for food adulteration). 98% of students said that smart-board-aided visual learning helped in easier grasp of scientific concepts (Fig. 4B & 4C). 89% of the students said they scored better in school examinations after attending the program.

3.5 Survey on dietary habits among students attending the ECAS program

Balanced nutritious meals and healthy snacks were provided to raise awareness on the importance of healthy eating for growth and overall cognitive development. The survey showed that in most cases the female parent prepared food for the family (Fig. 5A). In 50% of cases both parents contributed economically to the family, while in the rest one of the parents was the bread winner (Fig. 5B). Rice and vegetables were the main component of the diet, 66% ate at least one pre-ordered meal in a week, 19% consumed eggs daily, while 39% consumed eggs once or twice a week. 54% of the students consumed either tea or coffee daily, while only 21% consumed health drinks, fruit or vegetable juice. 59% included fish or meat in their weekly diet, while 31% included green leafy vegetables. Majority (87%) of the students drank purified water (canned). 83% of students had washrooms available at home, while 17% used shared washrooms. 76% of the students were vaccinated as per the National government vaccination protocols (Fig. 5H–J).

4 Discussion and conclusion

The ECAS program contributed to student overall academic progress, both in theory and practical science learning and also made it interesting. The customised course content delivered during the two week program using digital smart pedagogic methods with visual learning helped easier grasp of scientific concepts. Integrating practical laboratory based learning bridged the gap between theory and practice. Digital technologies can therefore be innovatively used to teach science by developing customised modules to meet student educational needs by integrating audio-visual information. These e-modules can be stored and can be made available to schools in remote areas where internet access is available. Further, tailoring e-modules to include school curriculum-based content, by simplifying science learning, has the potential to enhance academic performance in school. Students could consciously apply these scientific concepts to their daily lives and connect with events in their day-to-day life. Bilingual teaching (English and Tamil) contributed to

![Surveys](https://example.com/surveys.png)

Fig. 5  Survey on dietary habits among students attending the ECAS program
easy assimilation and understanding of scientific concepts. Use of the mother tongue/local language as a medium of instruction, will increase knowledge access and also promote the strength, usage and vibrancy of Indian languages. A supportive academic environment and approachable nature of teachers and ambient environment along with a training program of a competent standard can provide an academic advantage. Student confidence in accessing internet for scientific information and also handling the desktop system to access relevant information was increased. Awareness of internet-based learning resources/tools as secondary sources of learning (foster self-learning and curiosity) was increased. While most schools have the mid-day meal program (supplemented with egg), special attention needs to be paid to provide nutri-dense meal for overall cognitive development, better learning and physical growth. Personalized certificates issued upon course completion confers a sense of achievement. The ECAS program at MSSRF attempts to provide quality science education using digital technologies to integrate socio-economically marginalised students.

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Declarations

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References

1. https://sdgs.un.org/goals/goal4
2. https://disel.education.gov.in/rte
3. https://udiseplus.gov.in/#home
4. http://img.asercentre.org/galleries/aser2021_final.pdf
5. https://remia2021.fmi-plovdiv.org/wp-content/uploads/2021/10/4_2_Peykova_Garov_Digital-tools_21_28.pdf
6. https://cms.tn.gov.in/sites/default/files/documents/sedu_epn_2020_21.pdf
7. https://ishiksha.net/new-education-policy/
8. Talafian H, Galoyan T, Hammrich PL, Lamberson L (2019) Experiential learning in a summer program: engaging undergraduate students in STEM research experience. Summer Acad 12:1–26
9. Bobek E, Tversky B (2016) Creating visual explanations improves learning. Cognit Res: Princ Implic 1(1):1–14
10. https://s3-ap-southeast-1.amazonaws.com/dev-rekapin/download/collection/163-Mother-Tongue-Based-Multilingual-Education-in-Papua-Province-(2-of-2).pdf

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