

Integration of Technology in Teaching and Learning of Science: Challenges and Benefits of Online Education

Proceedings of Online One Day Teachers' Conference

SATURDAY, 5th FEBRUARY 2022

ONLINE ZOOM MEETING



Editors

Dr. Shirish Pathare

Homi Bhabha Centre for Science Education (TIFR), Mumbai

Dr. A. K. Rajarajan

Navi Mumbai Science Foundation, Navi Mumbai

Organised jointly by,

NAVI MUMBAI SCIENCE FOUNDATION,

NAVI MUMBAI

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION (TIFR), MUMBAI



Science Utsav 2022

A Humble Tribute to a Great Educationist



Navi Mumbai science Foundation (NMSF) considers itself privileged and honoured while acknowledging the support it received from late Prof. Chitra Natarajan during the short interactions conducting one-day event “Teachers’ Conference” in the the years 2013 to 2015. The seeds of “Teachers’ Conference”, which is a part of NMSF’s two-day event “ Science Utsav”, were sown in the year 2012, mainly under the guidance of Prof. Jayashree Ramadas, the then Dean of HBCSE (TIFR) and peripherally under Prof. Chitra Natarajan’s counsel. Next year onwards, of due to limited availability of Prof. Jayashree Ramadas, the responsibility of nurturing the year-old sapling fell on the shoulders of Prof. Chitra Natarajan. By this time, Prof. Chitra Natarajan had also assumed the responsibility of position of Dean, HBCSE (TIFR). She accepted this additional responsibility with all humility, despite her deep involvement in several other events and projects. We thus never got the feeling that she was looking after and adopted child.

It was during this interactions that we came to know about her and her personal qualities. No amount of words can describe all the facets of the charming personality and life as experienced by us at NMSF. She always had something more to contribute and enlighten us further in any area of our scientific endeavour related to the field of education, and especially those related to school students.

In her passing away, we at NMSF have lost a dear friend and a vibrant guide. However we are sure that her soul will be always around us in the hour of need and guide us intuitively. At our end we will continue to ensure that the now 10-year old plant of “Teachers Conference” will continue to prosper with leaps and bounds and add stature to the image of the departed soul. Already the signs of this happening are visible. We now find the teachers coming from places outside Navi Mumbai and taking advantage of the proceedings of the conference. It will, therefore, be not surprising if the roots of the event soon spread to district or state level.

Science Utsav 2022

Proceedings of Online One Day Teachers' Conference on

Integration of Technology in Teaching and Learning of Science: Challenges and Benefits of Online Education

Saturday, 5th February 2022

Online Zoom Meeting

Editors

Dr. Shirish Pathare

Homi Bhabha Centre for Science Education (TIFR), Mumbai

Dr. A. K. Rajarajan

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Navi Mumbai



Homi Bhabha Centre for Science Education

Mumbai



Navi Mumbai Science Foundation (NMSF)

An NGO's portal for innovation in Education

Navi Mumbai Science Foundation (NMSF) is a science led NGO in India. It is dedicated to development of “scientific culture” in the society in general & “scientific temper” in the student community in particular. This in turn contributes towards the holistic development of the nation & prepares it to face the challenges posed by a technologically advancing global environment without losing sight of its societal commitments. Its vision & mission may be summed up as under:

VISION

- Kindle and nurture scientific temperament in students;
- Enhance soft skills like problem-solving approach and communication skills;
- Promote ‘Pupil-centric’ approach in education;
- Create awareness in public about science and scientific issues;

MISSION

- To advance, popularize and promote the cause of science through a defined action plan.

ACTION PLAN

- **Develop a network** of professionals and personalities to share their knowledge;
- **Provide multi-disciplinary environment** to students to understand their inter linkages;
- **Provide a platform** for interaction between leading educationists, teachers and students.

The detailed action plan presently includes the following activities on an annual basis:

1. I. Interactive Guidance Sessions for “Homi Bhabha Bal Vaidnyanik Competition [HBBVC]” with Scientists & Research Scholars.
2. II. Science Nurture Club Activity (syllabus-based theory lessons & science-based project work) for students of Std. VII & VIII (separate Batches).

3. III. Guidance Sessions for “Regional Mathematics Olympiad (Pre-RMO & RMO Exams)”.
4. IV. Essay Competition on the topic “Nurturing Talent for Noble Laureatism”.
5. V. Fun with Science Programmes (as per request from Schools).
6. VI. Special Event: World Nuclear Energy Day celebration (Dec. 2, each year).
7. VII. Signature Event of NMSF: Science Utsav (a two-day event during February each year).
8. VIII. National Science Day celebration (Feb. 28, each year).
9. IX. Providing Judges for Science Exhibitions at Schools & Colleges (as per request).
10. X. Participation in Miscellaneous Scientific Activities at Schools & Colleges (as per request).
11. XI. Publication of a quarterly scientific E-Magazine - EduREKA - for students of Std. VI to X.
12. XII. Dr. Vikram Sarabhai Essay Competition on the general topic “Space Exploration” – introduced during the academic year 2020-2021.
13. XIII. National Mathematics Day celebration (Dec. 22, each year).
14. XIV. International Mathematics Day celebration (March 14, each year).

Together, all these activities can be referred to as “Extra-Curricular Scientific Activities”.

For joint scientific activities, please contact NMSF Members.

Our website: <http://www.navimumbaisciencefoundation.org>

Homi Bhabha Centre for Science Education

The Homi Bhabha Centre for Science Education (HBCSE), a centre of TIFR, is a unique institution in the education sector in the country. It is an interdisciplinary academic institution integrating humanities, social science and science disciplines. HBCSE's work is focussed at all levels of education, from primary to tertiary.

Research and innovation at HBCSE is of international repute and the centre has published its work in leading peer-reviewed journals, while it remains grounded in Indian contexts. Strands of research at HBCSE range from inquiry-based and enactive approaches to STEM education, curriculum development, teaching and learning school mathematics, design and technology education, environmental education, pedagogical content knowledge (PCK) for teachers, collaborative online platforms for science learning as well as "home-grown" model systems laboratories for undergraduate biology, cognitive bases of learning, discipline-based education research, etc. Students who graduate from HBCSE have excellent training and leadership capabilities which can provide a vision to the educational arena of the country.

HBCSE is also India's nodal centre for selection and training of Indian students for participation in the prestigious international Olympiads in astronomy, biology, chemistry, junior science, mathematics and physics. HBCSE's "Vigyan Pratibha" project is a talent nurture programme for secondary students of Kendriya Vidyalayas, Jawahar Navodaya Vidyalayas and Atomic Energy Central schools. Teachers are provided orientation and materials to run the programme through "science clubs". The materials developed are also translated into regional languages. Another programme of HBCSE, the "National Initiative in Undergraduate Science" exposes college students to research culture as they pursue research projects and are mentored by scientists. All these three programmes emphasize the experimental dimension of science, in addition to the theoretical aspects, which is often missing in the typical Indian science curriculum.

HBCSE has also developed its own curriculum and workbooks for primary science and mathematics, as well as contributed to curriculum and textbook development at the Central and State levels over the years. Several teacher professional development workshops are conducted round the year which are based on the latest developments in research and pedagogical innovation from around the world. The Centre has initiated collaborations with various teachers associations over the past years and supports institutions to reach out to the communities. Members of HBCSE are involved in disseminating their research and development via multilingual means and the

Centre also maintains an e-Hindi website containing resources in popular science. HBCSE also has expertise in the use of digital and communication technologies in supporting science learning, which are now more and ever relevant and needed in the pandemic aftermath.

HBCSE has a well resourced library that is open to the general public. It also organises a biennial conference titled epiSTEME that brings together researchers, teachers, students and grassroots workers in science, technology and mathematics education from across the world to share and build networks of collaborations.

Navi Mumbai Science Foundation

Science Utsav: Teachers' Conferences

Glimpses of the topics covered during previous Teachers' Conferences

Year	Main theme
2012	Hands-on Science in Schools
2013	Project Based Science Learning
2014	Demonstration of Science Experiments in High Schools
2015	Collaborative Learning: A Useful Teaching-Learning Method
2016	Encouraging and Supporting students' thinking in class room learning/ teaching of science
2017	Use of ICT in Teaching-Learning Process
2018	Moving towards a better understanding of the environment
2019	Subject and Pedagogical Content Knowledge in Science Teaching
2020	Effective science teaching-learning strategies for classrooms
2021	Developing Online Interactive Environment for Science Teaching and Learning
2022	Integration of technology in teaching and learning science: challenges and benefits of online education

Concept Note

Theme for Teachers' Conference 2022

Integration of technology in teaching and learning science: challenges and benefits of online education

Technological developments have and will continue to impact various aspects of our lives and education is one such area. In the recent pandemic and subsequent school closures, the technology of online schooling has played an important role in continuation of learning of a large section of students. With physical distancing many schools switched their physical laboratory courses to virtual laboratories; physical classrooms were replaced with virtual classrooms; and social interactions among school communities moved to the virtual spaces. However, there was little time to understand if these switching over adhered to good pedagogical practices that benefited students academically and socially. Moreover, some newer forms of inequities such as disproportionate access to resources for some students as well as teachers from marginalized groups became evident, perhaps compounding the pre-existing equity issues in education and society.

As we slowly begin our journey back towards the physical mode of schooling, it is a good time to reflect on what influenced our choices of certain technologies, what were our experiences, and how we envision the possible future with the newer technological advances. The topic of this year's teachers' conference "Integration of technology in teaching and learning science: challenges and benefits of online education" provides an avenue for teachers, researchers, and other stakeholders in education to disseminate, share, and discuss what did and did not work with the integration of technology in pedagogic endeavors.

Five sub themes of the conference

1. Use of technology in conducting science experiments

Technology-enabled classroom/laboratory is an innovative approach to teaching and learning of science. It helps students to engage in the learning process and to communicate the excitement and joy of discoveries in science. If you, as a teacher, experienced or used this approach in the classroom or in the laboratory; did it help in conveying certain concepts? Did it save your time? Was it an 'Aha' moment for your students? What were the challenges in using these technological tools?

Do you have any innovative ideas brought up by students? Share the experiences of innovative modes of using technology. It would also be great to share the instances which provided an opportunity to improve not only students' but also your conceptual understanding of science with the use of technology.

2. Learning loss in science and mathematics during pandemic

The pandemic has changed the way in which the classrooms (and to some extent laboratories) are being conducted. Implicit assumptions were made regarding the nature of student – teacher engagements and that these engagements were similar to the offline ones. However, students may not have been able to attend classes due to various reasons, such as the loss of near and dear ones as well as financial changes due to the lockdown. Families were thrown together and there were different struggles that we are aware of. What impact did all this have on students' learning? Did you notice anything unusual in the retention in day-to-day learning? Did you have doubts or confidence in the way students were learning? How did you modify online learning to accommodate these changed circumstances?

3. Teachers as facilitators in different learning environment

The role of teachers as the authority is predominant in most schools in India. Taking on the role of a facilitator demands a greater responsibility on the part of the teacher. It requires allowing students to explore and understand the concepts by creating a suitable learning environment that can inculcate a sense of ownership about the learning material. Needless to say, a lot of preparation by the teacher is necessary to create such a learning environment. If you have acted as a facilitator in your classrooms, did you face any problems? Do you think changing over to the role of a facilitator from authoritarian helps you in teaching faster and in a more productive way? Do share your experiences of creating such learning environments and whether technology played any role in this. Moreover, given the students were fluent with some technological aspects- does that aid making the classroom non-authoritative.

4. Issues of equity and access in using technology while teaching science

'Equal educational opportunities for all' has been an important goal of education. With the sudden switch to virtual classrooms, access to data and hardware resources did become an important issue for individuals and institutions. An immediate question to ponder is digital

equity in a society that already has great inequities. Schools also experienced issues related to access to high quality e-content for teaching, and access to training for using the content resourcefully and managing virtual classrooms. It is interesting to know how teachers, or teacher educators dealt with these challenges locally. Share any specific challenge that you experienced or observed about equity and access in your immediate circle.

5. Connecting science and society

Science is an integral part of our knowledge-based societies; and is driven by societal concerns. Have you been engaged in integrating social and scientific inquiries in class? Share your experiences of how you encouraged students to ask pertinent questions and analyze diverse opinions expressed in socio-scientific debates. Did you discuss pandemic or other than the pandemic related socio-scientific issues in class? How did you conduct these discussions in a technology-aided classroom?

Process of conference: The one-day online conference consists of a few invited talks by experts on this subject, and mainly, oral and poster presentations of “contributions by participating teachers”.

Sugra Chunawala
Chair-person, Advisory Committee

Advisory Committee		Organising Committee	
Prof. Sugra Chunawala	Chairperson	Dr. A. M. Bhagwat	Chairperson
Members		Dr. A. K. Rajarajan	Convener
Dr. A. M. Bhagwat		Dr. Shirish Pathare	Co-convener
Prof. Savita Ladage		Members	
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Dr. Aswathy Raveendran		Dr. D. A. R. Babu	
Dr. Reema Mani		Dr. K. P. Muthe	
Ms. Adithi Muralidhar			

Program

Navi Mumbai Science Foundation		
Science Utsav Teachers' conference 2022-Program		
5 th Feb 2022		
Time		
09:30-09:45	Welcome & Introduction	Dr. A.M. Bhagwat
	Introduction of the PCNML speaker	
09:45-10:15	Address by Chief Guest: Chitra Natarajan Memorial Lecture	Prof. Arnab Bhattacharya
10:15-10:35	Release of Proceedings	By Chief Guest
	Introduction / Felicitation of President Awardee	
10:25-10:35	Awardee's speech	Mr. Khurshid Shaikh
10:35-10:45	Break	
10:45-12:45	Session-I:	Chair: Prof. Savita Ladage
10:45-11:05	Invited Talk-1: Use of technology in conducting science Experiments	Dr. Shirish Pathare
11:05-11:45	Presentation of Papers - 1	O1 - O4
11:45-12:05	Invited Talk-2: Learning loss in science and mathematics during pandemic	Shri. Alok Katdare & Ms. Seema Lathkar
12:05-12:45	Presentation of Papers - 2	O5 - O8
12:45-13:30	Lunch Break	
13:30-15:50	Session-II:	Chair: Dr. Reema Mani
13:30 - 14:00	Poster presentation	P1 – P6
14:00-14:40	Presentation of Papers - 3	O9 – O12
14:40-15:00	Invited Talk-3: Issues of equity and access in using technology while teaching science	Dr. Dawood Vaid
15:00-15:20	Invited Talk-4: Connecting science and society	Dr. Aswathy Raveendran
15:20-15:50	Presentation of Papers - 4	O13 - O15
15:50-16:20	Concluding Session	
15:50-16:00	Summing up	Dr. A.K. Rajarajan
16:00 - 16:10	Feedback by Participants	
16:10-16:20	Vote of Thanks	Dr. D A R Babu

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Chief Guest's Speech
&
Prof. Chitra Natarajan
Memorial Lecture

The wonderful lab called home (in the pandemic, and beyond!)

Prof. Arnab Bhattacharya, Homi Bhabha Centre for Science Education (TIFR), Mumbai

The closure of schools due to the COVID-19 pandemic led to an unparalleled disruption in the educational system across the country, in a manner never seen before. While online classes have been pushed as a measure to ensure some continuity in education, the lack of connectivity and access to devices, especially for children in under-resourced communities



and government schools has meant that only a fraction of children have had online education of any kind. It has also been difficult for teachers to suddenly adapt to digital platforms. In most cases it is only bookish and theoretical information that has been conveyed. Especially for the learning of science, which can only be done through asking questions and doing experiment, the pandemic has been an outright disaster.

Even in the best of times, making the science curriculum exciting and inviting to a school student has been a challenge. Though science and technology underpin societal progress, there is a general lack of awareness in the Indian public, with science considered a difficult, boring but unfortunately compulsory school subject, and with not enough students taking science beyond high school.

An exciting experiment is often the best way to engender curiosity in a school student. The pandemic provided a catalyst to see how one could come up with interesting but thought-provoking experiments that could be done “at home”, with available materials and are hence easy to carry out in resource-constrained environments, even beyond the pandemic.

Thankfully, opportunities for doing interesting science experiments are all

around us, and often in the activities we often take for granted in our daily lives. I will show several examples where experiments at all school levels can be carried out at home and in our immediate surroundings (admittedly biased by my personal experience – i.e. mostly in a “city” home, mainly looking at what might be called “physics”). Some of these can be quantitative as well, and, as I will show, can even lead to research explorations that are publishable! While having smartphones with their various sensors can allow a whole range of even more sophisticated measurements to be done, there are enough experiments that can be done with just the very basic “apparatus” available in the kitchen, bathroom, playground etc. without sensors. From pouring rice grains and atta, to looking at boiling water for a cup of chai, and from hearing a bucket fill up to emptying water from a matka, there is a lot that can be made fun and engaging.

The wow of science is just waiting to be discovered. In the most wonderful lab called home!

Invited Talks

विज्ञानाचे डोळे

खुर्शीद के शेख, राष्ट्रीय शिक्षक पुरस्कार 2021 प्राप्त, जि.प.उ.प्राथ.शाळा
आसरअली, जि. गडचिरोली

शाळा हे असे एकमेव ठिकाण आहे जिथे विद्यार्थ्यांना विज्ञानाचे डोळे (Science Eyes) देता येते आणि या डोळ्यांनीच तो प्रत्येक गोष्टी अथवा घटनांमागील कारणमीमांसा शोधतो. माझ्या मते विद्यार्थ्यांना प्राथमिक शिक्षणापासूनच जर विज्ञानाशी मित्रत्व करून दिल्यास अतिशय उत्कृष्ट दिशा विद्यार्थ्यांना व देशालाही मिळेल. विज्ञानाला फक्त विषय समजून चालणार नाही तर जीवनाच्या मूळ प्रगतीचा आधार मानावे लागेल. यासाठी शिक्षकाची व शाळेची भूमिका महत्त्वपूर्ण आहे.

मी माझ्या विद्यार्थ्यांसाठी राबविलेले वैज्ञानिक उपक्रम:



- बाल विज्ञान नाट्य मंच (Child Science Drama Group):
विज्ञानाची आवड सहा ते चौदा वयोगटातील म्हणजे प्राथमिक स्तरावर करायची असल्यास ती विशिष्ट कलेच्या माध्यमातून द्यायला हवी. यासाठी मी माझ्या शाळेत बाल विज्ञान नाट्य मंच स्थापन केले व छोट्या-छोट्या नाट्यांच्या माध्यमातून विद्यार्थ्यांना विज्ञानातील शोध व संशोधक व विज्ञानाचे जीवनातील महत्त्व याविषयी माहिती दिली जाते व विद्यार्थी सहज ते स्वीकारतात.
- विज्ञानाच्या बातम्या प्रदर्शनी फलक (Science News Gallery Board):
विद्यार्थ्यांना देशात व जगात होणाऱ्या विज्ञानाच्या उपयोगाची व नवनवीन तंत्रज्ञानाच्या शोधांची माहिती मिळावी यासाठी तसेच जगातील वैज्ञानिक बदल माहिती व्हावे यासाठी माझ्या शाळेमध्ये विज्ञानाच्या बातम्या प्रदर्शनी फलक (Science News Gallery Board) असून असून विद्यार्थी व शिक्षक वर्तमानपत्रांतील विविध बातम्या या फलकावर लावतात. यामुळे विद्यार्थ्यांमध्ये शोधक वृत्ती वाढली असून विज्ञानाविषयी आकर्षणही वाढलं आहे. कारण विद्यार्थी या बातम्यांची चर्चा करतात व तर्कवितर्क लावतात यावरून ते विज्ञानाभिमुख होत आहेत हे कळते.
- ए. पी. जे. अब्दुल कलाम नाविन्यपूर्ण विज्ञान केंद्र – (Innovative Science Centre):
विज्ञान म्हणजे नावीन्यतेचा शोध म्हणून विद्यार्थ्यांना नवीन शोधण्यासाठी व प्रयोग करण्यासाठी या ए.पी.जे. अब्दुल कलाम नाविन्यपूर्ण विज्ञान केंद्र (Innovative Science Centre) मी माझ्या शाळेत केले आहे. यामुळे विद्यार्थ्यांमध्ये प्रयोगशीलता वाढली आहे.

- बाल वैज्ञानिक पुरस्कार (Junior Scientist Award):

दर वर्षी मी माझ्या शाळेत विज्ञान विषयक उत्कृष्ट कार्य करणाऱ्या विद्यार्थ्यांना बाल वैज्ञानिक पुरस्कार (Junior Scientist Award) देऊन सन्मानित करण्यात येते व त्यांना एक पदक व विज्ञानावर आधारित पाच पुस्तके भेट म्हणून दिली जातात. या पुरस्कारामुळे विद्यार्थ्यांना प्रेरणा मिळत असून शाळेत अनेक बालवैज्ञानिक उदयास येत आहेत.

- विज्ञान जत्रा (Science Fair):

विद्यार्थ्यांनी तसेच शिक्षकांनी आपल्या नवीन वैज्ञानिक संकल्पनेतून शोधलेल्या प्रतिकृतींची प्रदर्शनी या विज्ञान जत्रेतून केली जाते. यातून विद्यार्थ्यांना अतिशय आनंद मिळतो तसेच वैज्ञानिक दृष्टीकोण वाढतो आहे.

- Young Science Eyes Reporter (YSER):

आपल्या गावातील व परिसरातील विविध घटनांची माहिती वैज्ञानिक दृष्टिकोनातून योग्य ते विवेचन करून समाजापुढे मांडून अंधश्रद्धा दूर करण्याच्या हेतूने Young Science Eyes Reporter (YSER) ही संकल्पना पुढे आली. शाळेत अनेक यंग रिपोर्टर तयार झालेले आहेत जे समाजात विज्ञान जनजागृतीचे कार्य करतात.

विज्ञानाचे डोळे (Science Eyes) या प्रकल्पाच्या माध्यमातून माझ्या अतिशय दुर्गम भागात असलेल्या शाळेतही आज विद्यार्थी विज्ञानाकडे एक विकासात्मक शक्ती म्हणून बघतात याचा मनाला आनंद होतो. आज विद्यार्थी प्रत्येक बाब ही विज्ञानाच्या डोळ्यांनी बघतात हे विशेष.



Science Experiments and Technology

Dr. Shirish Pathare, Homi Bhabha Centre for Science Education,
Mumbai

Every year, schools insist that teachers should be aware and be equipped with the skill of handling different technological tools. These skills are to be learnt with the aim of passing them on to the students while conducting science experiments. At times, the teachers are even provided with the opportunities to attend some workshops for the same.



What do we mean by using technology in science experiments? Does that mean that the way science experiments are being done in school laboratory did not use the aspect of technology? The answer is - certainly not. In fact, science experiments have always been carried out with the help of technology. We have always used different kinds of instruments for measurements of physical quantities. Some of these instruments/tools get upgraded over time. Some of these tools are digitized with the advancing technology available in the market, making them more expensive. However upgradation of the instruments and scientific procedures and their use is as much an important part as the development of laboratory skills amongst students. Schools also have a covert responsibility of introducing students to all kinds of technology possible so that they can become equipped with the necessary skill set to explore the different ideas flourishing in their minds at present and in their future.

Additionally updating our tools with the upgrading technology and changing the way in which the experiments are performed in the laboratory, would not only make the same experiment more interesting but it may also save

time and make the measurement techniques at times convenient and reliable.

In my talk, I would introduce the audience with various sensors that are available in the market. These sensors are useful in conducting measurements in science experiments. Some of these sensors provide a good alternative to the expensive digital equipments. The application of some of these sensors will be discussed in my talk. This discussion hopes to provide a new outlook at developing or modifying the present science experiments in school laboratory.

Loss of Learning and Scaffolding for Learning Science and Mathematics During Pandemic

Alok Katdare, Seema Lathkar, Reliance Foundation School, Koparkhairane



Shri Alok Katdare



Dr. Seema Lathkar

Following topics are discussed in order to support the schools to address the learning gaps in the subjects of Mathematics and Science by providing practices and examples, concrete and strategic action plans

- Generic pointers on Learning Loss
- Specific Learning Loss in Science and Mathematics
- Parameters for measuring the Learning Loss
- Role of Assessment methods in Pandemic
- Teachers' training and its importance
- General suggestive scaffoldings
- Specific scaffoldings in Mathematics and science teaching

Change-maker's World

Dr. Dawood Vaid, Golden Sparrow Hub Schooling, Mumbai

Welcome to Global Goals. Together we

can. It's the awareness that calls for this hour and time. I decided to create an educational institution keeping the Global Goals in mind. And that implies all of us. The community of school leaders. From principals and those in the management. The students, obviously. Because in them, I see the future.



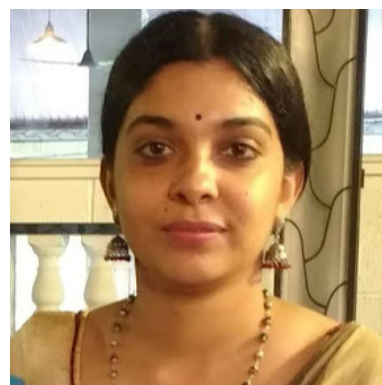
The new Gretas, Emmas and Malalas. Yes that Girl power and SDG 5 – Gender Equality.

The Sign Post are milestone indicator and it reflect a lot of work need to be done. Some of them are alleviating human suffering from the food crisis or fighting disease. Others are finding more sustainable source of energy. A lot of work has gone to make the **17 United Nation's Sustainable Goals**. Yet, most of us in the education fraternity are unaware or vague aware of the SDGs.

Science and society

Dr. Aswathy Raveendran, Homi Bhabha Centre for Science Education,
Mumbai

We are all aware that science, technology and society are deeply entangled. However, as members of the science education community, isn't it also our duty to convey the nature of the relationship between science, technology and society to our students? In this talk I will try to argue why this is necessary by providing an overview of the field of science



technology and society studies and its impact on science education. While science is a powerful knowledge system which has helped human beings understand and transform the world, it has also had devastating impacts on the world. The global environmental as well as the health crisis that the pandemic has exposed are good examples. The field of science-technology-society studies emerged in the decades after the second world war when the detrimental societal impacts of science and technology on society were increasingly being perceived by the scientific community and the public alike. By the 1980s, the necessity to incorporate science-technology-society concerns in school and higher education was also perceived and some science curricula especially in the global north incorporated these concerns. In my talk I will introduce you the field of science, technology, society studies and discuss how the field has impacted science education research and praxis. I will draw on the work I have done in my doctoral work (especially on commercial surrogacy) to provide an example of how these concerns can be incorporated in science teaching in the Indian context. We will also discuss how scientific and technological developments during the pandemic provide a context to discuss the interrelationship between science and society.

Contributed Papers

Use of Technology in Conducting Science Experiments

सौ. उज्वला कृष्णा खैरनार , न. मुं. मनपा शा. क्र. 1 बेलापूर

तंत्रज्ञानाचा विज्ञानात होणारा उपयोग समजून घेताना सर्वप्रथम आपण तंत्रज्ञान व विज्ञान म्हणजे काय ते समजून घेतले पाहिजे. विज्ञान म्हणजे काय?

निरीक्षण आणि चिकित्सक प्रयोगातून मिळालेली पद्धतशीर आणि तर्कसुसंगत माहिती म्हणजे विज्ञान होय किंवा दुसऱ्या शब्दात सांगायचं तर तर्कसुसंगत कार्यकारणभाव शोधण्याच्या प्रक्रियेतून विज्ञान वाढीला लागतं. आपण 28 फेब्रुवारी हा दिवस 'राष्ट्रीय विज्ञान दिन' म्हणून साजरा करतो, कारण भारताचे विज्ञानाचे पहिले नोबेल पारितोषिक मिळवणारे शास्त्रज्ञ सी. व्ही. रमण यांचा संशोधनाचा नोबेल मिरवणारा प्रबंध 28 फेब्रुवारी या दिवशी प्रसिद्ध झाला होता. थोडक्यात कोणताही निष्कर्ष प्रयोगातून तपासून घेता आला पाहिजे हे विज्ञानाचा आधार तत्व. विज्ञान म्हणजे नैसर्गिक चमत्कारच रहस्य उलगडणारे शास्त्र होय. उपयोजित विचार करणे म्हणजे विज्ञान होय.

विज्ञानाला तंत्रज्ञानाचा आधार घ्यावा लागतो. विज्ञान आणि तंत्रज्ञान यांच्या संबंधाचा विचार करता हे दोन्ही घटक आपणास एकच वाटतात. परंतु हे दोन्ही वेगळे आहेत. विज्ञानाची सत्यता पडताळून पाहण्यासाठी किंवा विज्ञानातील घटकांच्या प्रगतीसाठी तंत्रज्ञानाचा वापर केला जातो.

मग तंत्रज्ञान म्हणजे काय? तंत्रज्ञान म्हणजे व्यावहारिक हेतूसाठी केलेला वैज्ञानिक ज्ञानाचा वापर. विशिष्ट विज्ञानाच्या अभ्यासासाठी तंत्रज्ञानाचा वापर केला जातो तर तंत्रज्ञानाचा संदर्भ घेण्यासाठी विज्ञानाचा वापर केला जातो. तसेच विज्ञान आणि तंत्रज्ञानातील आणखी एक महत्वाचे अंतर म्हणजे विज्ञानात निरीक्षण आणि प्रयोग करणे समाविष्ट आहे तर तंत्रज्ञानात शोध आणि उत्पादन यांचा समावेश आहे. 'साधनांचा शोध आणि त्याचे उत्पादन' हे तंत्रज्ञानाचे पैलू आहेत.

वरील घटकांच्या विश्लेषणानंतर आपल्याला विज्ञान आणि तंत्रज्ञान यांच्यातील फरक लक्षात येतो. आपण सर्वजण गेल्या दीड दोन वर्षांपासून या आरोग्य समस्येला तोंड देत आहोत. कोरोना ने संपूर्ण जगाला स्तब्ध करून सोडले आहे. या जागतिक महामारी मुळे सर्वाधिक समस्या निर्माण झाल्या त्या शैक्षणिक क्षेत्रात. संसर्गाचा धोका टाळण्यासाठी 'लॉकडाउन' तसेच 'वर्क फ्रॉम होम' ही संकल्पना उदयास आली. त्याचाच परिणाम म्हणून आरोग्य विभाग सोडला तर सर्वच सामाजिक, आर्थिक, सहकारी संस्थांना आपला कार्यभाग हा वर्क फ्रॉम होम या संकल्पनेतून चालवावा लागला. सर्वच क्षेत्रात ही संकल्पना यशस्वी ठरू पाहत असताना शैक्षणिक संस्थांना मात्र मर्यादा आल्या. कारण शिक्षण ही जैविक देवाण-घेवाण प्रक्रिया असल्याने अनेक अडथळे निर्माण झाले. या सर्वांवर मात करण्यासाठी आपल्याला तंत्रज्ञानाचा आधार घ्यावा लागला. पूर्वीच्या काळात आश्रम व्यवस्था होती. पुढे त्यास गुरुकुल पद्धतीचे सार्वत्रिकीकरण होऊन शाळा व महाविद्यालये उदयास आली. 'सर्वासाठी शिक्षण' या धोरणातून सर्वत्र शिक्षणाची दारे खुली झाली. देशाच्या कानाकोपऱ्यात शिक्षण जाऊन पोहोचले. सर्व शिक्षा अभियान व त्यानंतर समग्र शिक्षा अभियान राबवून ज्ञानगंगा घरोघरी जाऊन पोहोचली.

कोविडच्या महामारी काळात शिक्षणाची त्रिसूत्री थांबली. शिक्षक शाळा विद्यार्थी यांच्यातील अंतर एकदम वाढले. शिक्षक विद्यार्थी आंतरक्रिया पूर्णतः ठप्प झाली आणि या सगळ्या परिस्थितीत शिक्षणाची अध्ययन-अध्यापन प्रक्रिया चालू करण्यासाठी आपल्याला मदत केली ती तंत्रज्ञानामुळे अवगत असलेल्या अनेक प्रकारच्या शैक्षणिक तंत्रज्ञानानी. त्यातूनच उगम झाला तो ऑनलाईन एज्युकेशन या प्रणालीचा. 'Learn from home' व 'Work from home' या हत्याराचा उपयोग करून शिक्षणाची क्रिया अखंडपणे चालू ठेवण्यात आपल्याला यश मिळाले. ऑनलाईन शिक्षण प्रणालीचा टेक्नॉलॉजी हा आत्मा बनला. जर टेक्नॉलॉजी नसती तर शिक्षणासाठी अनेक समस्या निर्माण झाल्या असत्या. शिकणे व शिकविणे ही प्रक्रिया पूर्णपणे ठप्प झाली असती. कदाचित जर टेक्नॉलॉजी नसती तर शिक्षणाच्या प्रवाहात दोन बाबींचा गॅप निर्माण झाला असता. इतिहासात दोन वर्ष नो एज्युकेशन किंवा झीरो एज्युकेशन अशी नोंद झाली असती. Thanks for Technology.

माझ्या मते तंत्रज्ञानाचा उगम हा विज्ञानातून झाला आहे. विज्ञान हे मूळ आहे तर विज्ञानाने तयार केलेले तंत्रज्ञान हे मानवाचे प्रगतीचे सर्वात मोठे हत्यार आहे. नैसर्गिक आपत्तीला तोंड देणे व त्यातून सहीसलामत बाहेर पडणे केवळ तंत्रज्ञानामुळे शक्य झाले आहे. आज या तंत्रज्ञानामुळे आपली शिक्षक विद्यार्थी, शाळा यांच्यातील आंतरक्रिया टिकून आहे. असे म्हणतात की शिक्षण ही अविरत सतत चालणारी प्रक्रिया आहे. या प्रक्रियेस अबाधित ठेवण्याचे काम या जागतिक संकटात तंत्रज्ञानाने केलेले आहे. आता आपण बघूया की टेक्नॉलॉजीचा शिक्षकाने व विद्यार्थ्याने अध्ययन-अध्यापनात कोण कोणत्या माध्यमातून उपयोग करून घेतला.

विज्ञान व तंत्रज्ञान यांच्या मदतीने शैक्षणिक क्षेत्रात जे तंत्रज्ञान विकसित केले गेले त्यालाच शैक्षणिक तंत्रज्ञान किंवा educational technology असे म्हटले जाते. म्हणजेच ऑनलाईन शिक्षण देण्याचे व घेण्याचे तंत्रज्ञान त्यात अनेक प्रकारच्या ॲप्लिकेशनचा अंतर्भाव होतो.

1) Educational apps, 2) Youtube, 3) Google meet, 4) Google classrooms, 5) Whatsapp, 6) Telegram ही थोडक्यात दिलेली उदाहरणे आहेत. या तंत्रज्ञानात कोविड-19 च्या काळात अतिशय वेगाने निर्मिती झाली, अनेक पर्याय उपलब्ध झालेत. Educational technology is concerned with the developments application and evaluation of system, techniques and aids to improve the process of human learning.

या शैक्षणिक तंत्रज्ञानाचे उद्देश हे शिक्षणाच्या उद्दिष्टाने प्रमाणेच दिसून येतात ते म्हणजे 1) पाठ्यपुस्तक व पाठ्यक्रम, अभ्यासक्रमाचे विश्लेषण करणे, 2) राष्ट्रीय गाभा घटक व मूल्यांची जोपासना, 3) माहितीचे संप्रेषण व विश्लेषण करणे, 4) मूल्यमापन प्रणालीत सुधारणा करणे, 5) ज्ञानाचे संचयन व विकास करणे, 6) विद्यार्थ्यांचा शारीरिक, भावनिक, बौद्धिक थोडक्यात विद्यार्थ्यांचा सर्वांगीण विकास करणे. थोडक्यात यास उद्दिष्टांच्या विकासासाठी व अध्ययन निरुत्पत्ती घडविण्यासाठी शिक्षण देणे आपला उद्देश असल्याने हा उद्देश पूर्ण करण्यासाठी टेक्नॉलॉजी आपणास सहाय्यभूत होत आहे. तंत्रज्ञानाचे अनेक फायदे आपल्याला करून घेता येतात ते असे:

1. शिकण्याच्या व शिकविण्याच्या पद्धतीत सुधारणा करणे
2. क्लिष्ट संकल्पना समजून देणे

3. जागतिक समस्यांची उकल करणे
4. विद्यार्थ्यांना जगाची ओळख करून देणे
5. शिक्षण पद्धती शिक्षार्थी केंद्रित करणे
6. माहिती व संप्रेषण यामुळे शिक्षणाचा दर्जा उंचावणे

वरील सर्व बाबींचा विचार करता असे लक्षात येते की शिक्षणात आमूलाग्र बदल घडविण्यासाठी, शैक्षणिक क्रांती घडविण्यासाठी आपल्याला तंत्रज्ञानाची मदत घ्यावी लागणार. या शैक्षणिक तंत्रज्ञानाचा सर्वाधिक उपयोग हा या कोविड काळात झालेला आहे.

विषयांच्या अध्यापनाचा अध्ययनाचा विचार करता अनेक विषय विद्यार्थी वाचन व परिसरातून शिकू शकतात. पुस्तकांच्या वाचनातून, मार्गदर्शनातून आपले ज्ञान प्राप्त करू शकतात. परंतु विज्ञान विषय शिकताना मात्र त्याला मर्यादा येतात का? या काळाचे उत्तर असे की विज्ञान हा विषय 80 टक्के निष्कर्ष व प्रयोग यांच्या माध्यमातूनच समजून घ्यायचा असतो. शाळा बंद मग प्रयोग कसे करायचे. काही संकल्पना इतक्या क्लिष्ट आहेत की त्या अप्रत्यक्षपणे समजून घेता येणार नाहीत. उदाहरणार्थ पेशीची रचना, मानवी शरीराची आंतरेंद्रिये, असे व वैद्यकीय क्षेत्रात तर प्रत्येक संकल्पना समोर बघणे, रसायनशास्त्रातल्या केमिकल रिएक्शन. मग केवळ पाठ्यपुस्तक वाचन शिकणे म्हणजे पाण्यात उडी न मारता पोहायला शिकणे. अशा समस्येवर एकच उपाय. चलचित्र, दृक्श्राव्य साधनांच्या सहाय्याने कृती करणे, बघणे व यासाठी आपणास या एज्युकेशनल ॲप्लिकेशनचा मोठ्या प्रमाणावर उपयोग झाला.

सरकारने विद्यार्थ्यांसाठी वाचनालय क्रीडांगणे, मैदाने, स्पोर्ट्स क्लब, संगीत अकादमी सगळीकडे गावोगावी उभारल्या. परंतु कोठेही विद्यार्थ्यांसाठी प्रयोग शाळा उघडण्यात आल्या नाहीत. त्याला कारणही तसेच आहे प्रयोग शाळा म्हटली की त्यात रासायनिक घटकांचा अधिकाधिक समावेश असतो. अशी रसायने ही मान्यता प्राप्त संस्थांमध्ये नियंत्रणाखाली वरिष्ठांच्या मार्गदर्शनाखाली हाताळायची असतात. त्यांना हाताळण्यासाठी प्रशिक्षणाची आवश्यकता असते. म्हणूनच प्रयोगशाळा या विशिष्ट संस्थांच्या अधिपत्याखाली निर्माण केल्या जातात. संभाव्य धोके, जीवितहानी, प्रदूषण, आरोग्य यांच्या दृष्टिकोनातून प्रयोगशाळेचे सार्वत्रिकीकरण केलेले नाही.

या समस्यांवर उपाय व मात करण्यासाठी शिक्षकाने आधार घेतला तो एज्युकेशनल टेक्नॉलॉजी अर्थात झूम ॲप, गुगल मीट, गूगल क्लासरूम चा. शिक्षकाने जे जे प्रात्यक्षिक केले ते झूम मीटिंग द्वारे विद्यार्थ्यांसमोर लाईव्ह करून दाखवले. का? कसे? अशा प्रश्नांची उत्तरे विद्यार्थ्यांसमोर दिली. तेही सोशल डिस्टन्स पाळून. आहे की नाही जादू. स्वतःच्या घरात बसून विद्यार्थ्याने प्रयोग शाळेत घडणाऱ्या प्रयोगाचा निष्कर्ष काढला. It happened only due to technology.

जीवशास्त्रातील प्राणी पेशी, वनस्पती पेशी शाळेत विद्यार्थी मायक्रोस्कोप मध्ये डोळे बारीक करून बघू शकत नव्हता; पण युट्युब च्या मदतीने विद्यार्थी डोळे उघडे ठेवून, दोन्ही डोळ्यांनी पाहू शकतो. मानवी शरीरातील रचना, आंतरेंद्रिये जी प्रयोगशाळेत प्रतिकृतीच्या माध्यमातून बघत होता, ती रचना युट्युब, क्रोम च्या माध्यमातून आपण जिवंतपणे बघितल्या सारखा अनुभव घेऊ शकतो. 3D तंत्रज्ञानाच्या मदतीने आभासी कल्पना मूर्त

स्वरूपात व्हिडिओद्वारे पाहू शकतो.

भौतिकशास्त्रातील अनेक संकल्पना डोक्यात जाताना डोक्याचा अगदी भुगा होतो. गुरुत्वाकर्षण बल शिकवि-
ताना गुरुत्वाकर्षण म्हणजे पृथ्वी सर्व गोष्टी आपल्याकडे खेचून घेते एवढेच समजायचे. पण कसे घडते हे लक्षात
यायला बराच कालावधी जायचा. विमान कसे उडते ते खाली का पडत नाही? पृथ्वीची गुरुत्वीय कक्षा डोक्यात
जाताना डोक्यातील मेंदूला झोप यायची. आता एका सर्च वर आपण यूट्यूब च्या माध्यमातून वरील संकल्पना
समजून घेऊ शकतो. पूर्वी बऱ्याचशा संकल्पना केवळ प्रश्नार्थक दृष्टीने पाठांतर करून लक्षात ठेवल्या जायच्या.
केवळ निरर्थक पोपटपंजी करून विद्यार्थी पाठांतराच्या जोरावर परीक्षा उत्तीर्ण व्हायचा. प्रत्यक्ष अनुभव मात्र शून्य.
त्याच्या आजूबाजूला घडणाऱ्या अनेक समस्यांची व प्रश्नांची उत्तरे त्याला केवळ तंत्रज्ञानामुळे मिळू लागली.

तंत्रज्ञानाचा सगळ्यात मोठा फायदा असा की विद्यार्थ्यांच्या जिज्ञासू वृत्ती ला मिळालेला वाव. वर्गात अथवा
प्रयोगशाळेत प्रात्यक्षिक बघताना अनेक विद्यार्थी दडपणामुळे, व साहसामुळे किंवा आत्मविश्वासाच्या अभावामुळे
प्रयोग समजला नसेल तरी समजला नाही हे सांगण्याचे धाडस दाखवत नाही. अशा विद्यार्थ्यांसाठी युट्यूब वरील
प्रयोगाचे 3D इफेक्ट असलेले व्हिडिओ खूप मदत करतात. परिसर अभ्यास तसेच भौगोलिक विज्ञान शिकताना
सुद्धा तंत्रज्ञानाचा खूपच उपयोग होतो. आपली सूर्यमाला केवळ चित्राद्वारे पाठ्यपुस्तकात पाहून आपण अभ्यासू
शकत होतो. भौगोलिक विज्ञानातील निरीक्षणे नोंदताना या तंत्रज्ञानाच्या अप्लिकेशन चा पुरेपूर उपयोग होतो.
ग्रह, तारे, त्यांची रचना, गती यांचे प्रात्यक्षिक सुद्धा पुस्तकातील लेखनाच्या माध्यमातूनच समजून घ्यावे लागा-
यचे. पृथ्वीचे फिरणे, परिवहन, परिभ्रमण समजवताना शिक्षक स्वतःभोवती फिरून फिरून थकायचे, पण पाच
टक्क्यांपेक्षा जास्त विद्यार्थ्यांच्या डोक्यात ती जायची नाही.

आज युट्यूब मध्ये जाऊन किंवा अनेक जिओग्राफिक ॲप्स, सोलर सिस्टिम ॲप्स द्वारे विद्यार्थी सर्व संकल्पना
घरात बसून समजून घेऊ शकतो. पृथ्वीवरील आणि पृथ्वीबाहेरील नैसर्गिक घटनांचे प्रयोगाचे निष्कर्ष विद्यार्थी
व शिक्षक तंत्रज्ञानाच्या मदतीने उलगडू शकतात.

विज्ञानाच्या अनेक शाखा आहेत, उदाहरणार्थ, जीव, भौतिक, रसायन, भौगोलिक, सामाजिक, खगोल, शरीर,
भूचुंबकीय. सर्व शाखा प्रयोगाच्या व निष्कर्षाचे च्या आधारावर कार्य करत असतात. अगदी गणितीय शास्त्रात
सुद्धा प्रत्येक सिद्धांत पडताळून पाहताना प्रयोगाचा आधार घ्यावा लागतो. प्रमेयांचा स्पष्टीकरणासाठी आकृत्यां-
च्या व नियमांच्या जाळ्यात विद्यार्थी इतका अडकतो की त्याचा काटकोन त्रिकोण कधी होतो हे त्यालाच कळत
नाही. अशा क्लिष्ट संकल्पना अर्थातच प्रयोगांची पडताळणी शिक्षक समोर शिकवताना समजत नाही तर पुस्तक
वाचून कसे समजणार? पण या ऑनलाईन अध्ययन अध्यापनात मात्र केवळ तंत्रज्ञानाच्या मदतीने अभ्यासक्रम
शंभर टक्के यशस्वी पणे विद्यार्थ्यांपर्यंत पोहोचविण्याचे काम टेक्नॉलॉजीमुळे शक्य झाले आहे. कोरोना काळात
180 देशातील जवळजवळ एक ते दोन Billions विद्यार्थी शाळेपासून दूर राहून शिक्षण घेत आहेत. आणि मह-
त्वाची गोष्ट म्हणजे या कोविड च्या काळात ऑनलाईन एज्युकेशन प्लॅटफॉर्म मध्ये 18.66 टक्क्याने वाढ झाली
आहे. थोडक्यात ऑनलाईन एज्युकेशन एप्लिकेशन्स हा आत्ताच्या शिक्षण क्षेत्राचा आधारस्तंभ बनलेला आहे.
जेथे आर्थिक कारणाने ऑनलाईन प्लॅटफॉर्म उपलब्ध होऊ शकत नव्हता तेथे ही सरकारच्या मदतीने ऑनलाईन
एज्युकेशन साठी multilearning channels, शैक्षणिक दूरदर्शन, शैक्षणिक रेडिओ, वेब आधारित सूचना, शो-

धासाठी ग्रंथालये, माहिती संप्रेषण साधने दूर दूर पर्यंत पोहोचविण्यात आली. स्वयम सारखा आधुनिक प्लॅटफॉर्म सरकारने तयार केला असून त्यात 143 प्रकारचे ऑनलाइन कोर्सेस मोफत उपलब्ध आहेत. आज जवळ जवळ या ॲप्लिकेशनचा 2,26,547 जणांनी लाभ घेतला आहे. Virtual classroom च्या माध्यमातून शासकीय यंत्रणा आपले काम चोख पणे पार पाडत आहेत.

थोडक्यात मला असे म्हणायचेय की शिक्षण म्हणजे शाळा आणि विद्यार्थी एवढाच संकुचित विस्तार नसून मा-नवी जीवन सुखकर करण्यासाठी केलेला प्रत्येक प्रयोग विज्ञान आहे व त्याला यशस्वी करण्यासाठी तंत्रज्ञानाचा उपयोग झाला आहे.

Integration of technology in teaching and learning science challenges and benefits.

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Introduction

The covid-19 has resulted in school shut across the world. Globally over 1.2 billion children are out of their classrooms. As a result education has changed dramatically with the distinctive rise of e- learning whereby teaching is undertaken remotely and on digital platforms. Every classroom every, teacher and every student is different .Now teachers should be ready to the ever changing needs of students and classrooms by adopting different teaching styles, types of learners and educational environment.

Students are more successful when they are actively engaged in learning. Our teaching should put philosophy at the core of every lesson focusing on a big idea that engage students in fun enquiry based learning experiences. Our online education should offer

1. Teaching that stimulate sensory exploration
2. Activities that immerse student in subject matter
3. Experiences that students will retain throughout their education

What I'm using in online education?

- Videos on different topics created by expert teachers .eg.explore science based websites with educational videos
- PPT on different topics.
- Animation- Animated videos that explains and demonstrates how the planets rotate around the Sun.
- Listen to podcasts- sometimes breaking up the norm can help with students engagement as well .This will give them different method for

learning information. There are countless science podcasts available on internet.

- Play lesson games- There are many Science based interactive games available on internet , for eg. Science Bingo, Science dictionary ,What is in the world? etc.
- Virtual field trips- Students love to see new places and learning about new things right from the comfort of their science class room with access to virtual field trips.
- Google form- I am still using it for recording student responses on given topics. It helps me in creating puzzles, making reading faster and easier.

Challenges I faced

- There is no liveliness. Sometime it becomes very formal and not suitable for small children.
- All sensory organs are not wisely used in this method.
- Not every student can be examined everyday.
- Not every student can give feedback separately.
- The teacher does not understand whether everyone is listening or not while teaching.
- Sometime they may have internet or device issues.
- Some students are not very much friendly with technology.
- Poverty and gender discrimination
- There is less live interaction between students and teacher.
- Very less chance to do science experiments.

What can be done to solve these problems

- Weekly meeting and review

- Specific feedback on teacher work from students and parents
- Get daily reports via WhatsApp on Google forms.
- Call 2-3 students and ask them to send their work to the group.
- Specific feedback on student work should be given in the group.
- Positive reinforcement can be done by appreciating the students in the WhatsApp groups.
- For science experiments give as many as alternatives you can to the students.
- Take help from parents and elders of the students. This leads to higher parental engagement ,increasing parental interest in child education.
- Best Achiever- Oneday change the name of the students WhatsApp group to best achiever.
- keeping photo for 1 week the picture drawn by the student, the figure, the well solved math.
- Star of day - Online teaching activities should be fun. The activities should be encouraging to students. Teachers can announce the star of the day based on the performance of the students.
- Interaction with students who have difficulty completing task-based on WhatsApp on normal calls. The message goes that teachers pay attention ,teacher resolve doubts and evaluate progress on an individual level.

Benefits of online teaching

- Online education enables us to learn from various mentors and teachers in different areas increasing our knowledge and perspective.
- Enables the student to learn at their own pace.
- Individualized schedules- helps the student to pursue their passion.

- Greater learning option for students- learning at the tip of smartphone.
- Learn from qualified teachers- there are many online classes providing science education at one click.
- Easier attendance - you can learn from the comfort of your home. Due to the outbreak of the infectious covid-19 it sounds better to stay and learn from the comfort of our homes.

Online laboratory — a different perspective to do experiments

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Introduction

In the time of pandemic, many studies suggest the loss of learning in online setup of education. Specifically for the experimental part of the curriculum, lack of availability of laboratory apparatus led to learning inconsistency. For, this many universities came up with different solutions which prominently include use of simulations, images and videos of the experimental procedure to generate the data. Many colleges have adopted the method of sharing videos and images to students to generate data for particular experiment and getting desired results out of it. For simulation-based experiments, some colleges used the PhET simulation for various experiments in which students can change different parameters to collect the data and desired results. In another way of using online platform, the website provides the images and videos for the performed experiment in laboratory. This gives students the sense of how the experiment is working using actual setup.

In simulations, various parameter changes can lead to exploratory projects but, in this case, also students are just collecting data. The skills for understanding the procedure and choosing of apparatus is lacking. The second method gives students the idea about how different apparatus function and data collection using the method prescribed. However, it makes the experiment constrained to the information provided by the resources and leaves hardly any scope for independent thinking.

This motivated us to develop the webpages which will put students in the driving seat and allow them to take decisions about choice of instruments,

collection of data, range of data etc. The webpage is <https://shirishpathare.com> (figure 11.1).



Figure 11.1: The webpage

The structure of the experiment on website is similar to laboratory manual, where the detailed description and images for the apparatus and setup of the experiment is given. In the procedure part, a student has to analyze the video or images of the measurements and generate the data for variables in the experiment in a slightly different manner. Different procedural understanding aspects were employed in this section in the write-up. The experiments are:

- Angular speed of ceiling fan
- Repulsive force between magnets

These experiments were given to students as a pre-assignment for two online camps. Detailed discussion about the experiments and students' responses was conducted after they submitted their assignments.

The experiments

- Angular speed of ceiling fan

In this experiment, students are provided with the slow-motion videos for 5 speeds of the rotating ceiling fan. These videos were recorded using an android mobile phone. While recording the motion of the fan, another mobile phone with a running stopwatch was placed in the frame of recording (11.2). In this experiment we wanted students to

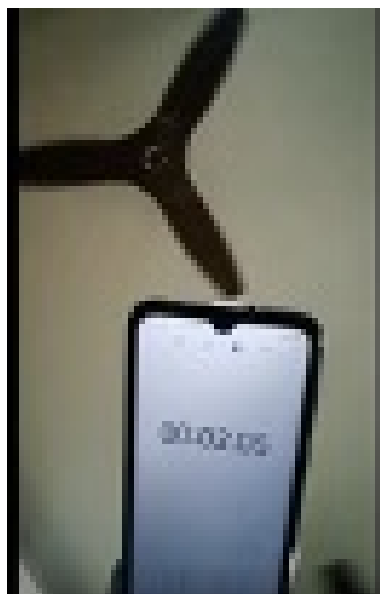


Figure 11.2: Screenshot of the video

study the variation in the angular speed of the fan at five different regulator knob positions. By looking at the videos, students are asked to generate the data with 1% uncertainty to get the value of angular speed. They are expected to do this at every regulator knob position.

Note on uncertainty in time measurement

In this case, the stopwatch provided in the video had a least count of 0.01s. With this least count, students were asked to decide on the number of rotations to be counted to tolerate 1% uncertainty in the measurement. For 1% uncertainty, the minimum time measurement that can be done with this stopwatch is 1.00s. But due to the human reaction factor, we cannot be precise in data collection. We anticipate the variation in time measurement by carrying out multiple trials. To overcome the problems due to human reaction factor, students are advised to consider a least count of 0.1s so that for 1% uncertainty a minimum measurement of 10.0s should be made. Student should decide the number of rotations that should be measured to complete 10.0s.

Discussion with students:

In the discussion session, students were first questioned that 'Does the human reaction factor play a role while measuring time in a video?'.
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Videos can be processed at slow rate to give more accurate results and hence the minimum time measurement that is expected to be taken is 1.00s for this experiment. The second part of the discussion was about multiple trials of the time measurement. As for a regular offline laboratory course experiments like simple pendulum, students are required to take multiple time measurements to take care of the random uncertainty involved in the measurement. In the video, as the students have the freedom to carefully adjust the slider position, random uncertainty made negligible. Hence the need of multiple measurements vanishes.

- Repulsive force between magnets

The study of magnets and magnetic force is introduced to the students in Grade VIII or IX in schools. Students are introduced qualitatively to the nature of attractive force and repulsive force between two magnets. They understand that the forces of attraction and repulsion become weaker as the magnets are moved away from each other. In this experiment, we explore how repulsive force between two strong magnets change with distance between them.



(a) Experimental setup of the repulsion experiment



(b) The webpage

As seen in the image (fig 3) one of the magnets is placed on a weighing pan of 0.1 g least count. The reading of the weighing pan is set to 0. Another magnet is placed over it in a repulsive mode. The weight of second magnet is balanced by the repulsive force between magnets. The weighing pan displays the magnitude of this repulsive force as the second magnet levitates above the first magnet. The position of the second magnet is fixed using a screw arrangement and the distance

between the two magnets can be measured using an acrylic scale of 0.1cm least count placed beside the arrangement. Photographs of the arrangement were given to the students in which they can measure the distances between the magnets and also record the corresponding reading of the weighing pan. The students were asked to perform the measurements with 2% uncertainty. With the least count of 0.1 cm, 2% uncertainty in distance would mean a minimum length measurement of 5 cm. All the distances given in the photograph have distances less than 5 cm. It is expected that students devise an appropriate method to meet the criteria of 2% uncertainty.

Discussion with students:

In our session with students discussion was carried out about the measurement methods. One can use a second scale of least count 0.1 cm and magnify the picture such that distance measured between edges of magnets using second scale is more than 5.0cm. The measurement made would thus be within 2% uncertainty. To get the actual length in the photograph, the magnification of the picture can be calibrated by finding the proportionality between the length measured using second scale and the same length represented by the scale in the picture. The force between magnets is usually defined from centre of magnets, but within the magnification possible it is not convenient to locate the centre of magnets. Therefore, the students are expected to consider the measurements from edge of the magnets as the magnets are of same dimensions.

Discussion

For both the experiments, we got positive responses from students. As per our discussion with students, we could gather that, in conventional school laboratories, students performed experiments with limited set of instructions, which hardly created any enthusiasm towards experiments. These instructions do not leave any room for students to think.

S: "...earlier I thought there is no 'creativity' in experiments and it was because in our schools we are all given everything by teachers."

In our online lab experiments, they were given probing questions and not a full-fledged procedure to perform different tasks. These probing questions made them think and come up with appropriate methods to meet the uncertainty criteria. Students acknowledged that the process of brainstorming was enjoyable.

S: "...all the experimental techniques shown were new to me...I enjoyed it."

S: "...all of the experiments were interesting and thought provoking."

In normal school laboratory setup students are instructed to perform the experiment using specific instruments. In our online lab experiments, students were given the criteria for carrying out measurements. They were given the freedom to make the choice of suitable instrument.

S: "...with this online laboratory I got to learn some experimental skills and how we may improve our graphs, observations and use of variables. I liked the choice of instruments part and how we approach to different measurements in different fields by minimizing errors."

The online laboratory exercises currently given to the students in schools, does not give any weightage to test students' skills for performing the measurements whereas in our case, the students got an opportunity to use their skills and devise suitable methods of measurements.

S: "...it improved my thought process in choosing the most accurate and efficient way to do an experiment."

Many students expressed that this exercise of online laboratory inspired them to do experiments with the material available at home.

Conclusion

We feel that our online laboratory experiments gave students better understanding of handling the basic instruments. These tasks involving choice of instruments and devising suitable measurement methods equipped students with better techniques. This also made them think critically regarding various aspects of planning an experiment. We feel that a short course of such techniques before performing the experiment in actual offline lab would enable the students to appreciate the finer details involved in performing experiments.

Use of technology in conducting science experiment

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एकविसावे शतक हे 'विज्ञान व तंत्रज्ञानाचे' शतक म्हणून ओळखले जाते. विशेषतः अठराव्या शतकानंतर मानवाने आपली प्रगती अतिशय वेगाने केली आहे. आजच्या युगात विज्ञान व तंत्रज्ञान मानवी जीवनाचा अविभाज्य अंग बनले आहे. आजचे मानवी जीवन पूर्णपणे विज्ञानाने व्यापलेले आहे. विज्ञान व तंत्रज्ञान शिवाय मानवी जीवनाची कल्पना करू शकणार नाही म्हणूनच विज्ञान व तंत्रज्ञानाचा अभ्यास ही काळाची गरज आहे.

ऑक्सफर्ड इंग्रजी शब्दकोशानुसार विज्ञान 'बौद्धिक आणि व्यवहारिक' क्रियाकलाप आहे. ज्यात भौतिक आणि नैसर्गिक जगाच्या संरचनेचे आणि अभ्यासाचे प्रयोग यांच्या माध्यमाने व्यवस्थितपणे केला जातो. विज्ञान ही एक जागतिक क्रियाकलाप आहे. जिचे प्रत्येकजण समर्थन करतो. विज्ञान असे काहीतरी आहे जे चालू आहे. साधारणपणे शैक्षणिक संस्थांमध्ये तंत्रज्ञानाच्या संदर्भात विज्ञान बोलले जाते. थोडक्यात विज्ञानाचा एक पद्धत-शीर ज्ञान पाया म्हणतात. विज्ञान विविध शाखांप्रमाणे भौतिकशास्त्र, रसायनशास्त्र आणि जीवशास्त्र या सारख्या पैलूंचा अभ्यास आहे. विज्ञान निरीक्षण आणि प्रयोग यांचा समावेश आहे.

तंत्रज्ञान म्हणजेच 'वैज्ञानिक ज्ञानाचा वापर' होय एखाद्या विशिष्ट विज्ञानाच्या अभ्यासासाठी तंत्रज्ञानाचा वापर करणे आवश्यक ठरते. उदाहरणार्थ ऊर्जा अभ्यासात प्रगती झाल्यामुळे ऊर्जा आणि वीज निर्मितीसाठी वापरलेल्या सौर पॅनलच्या तंत्रज्ञानाच्या विकासाचा चालना मिळाली. अशाप्रकारे विशिष्ट शाखेचा तंत्रज्ञानाच्या विकासात विज्ञानातील एखाद्या विशिष्ट शाखेचा उपयोग करण्यास मदत होते. तंत्रज्ञानाच्या अंमलबजावणी साठी लागणाऱ्या विज्ञान क्षेत्रातील प्रगतीसाठी त्याच्या प्रक्रिया पूर्ण करणे आवश्यक आहे.

'निरीक्षण, प्रयोग व निष्कर्ष' अशा प्रक्रियेतून निर्माण झालेले सामान्य तत्व म्हणजे विज्ञान होय. सभोवतालच्या पर्यावरणातील जैविक व अजैविक घटक आतील आंतरक्रिया जाणून घेण्यासाठी मानवाने केलेले सातत्यपूर्ण निरीक्षण प्रयोग निष्कर्ष या प्रक्रियेतून मिळवलेले ज्ञान हे तंत्रज्ञानावर आधारित असणे आवश्यक आहे. वैज्ञानिक ज्ञानाचा वापर मानवी कल्याणासाठी, आनंदासाठी, सुख-समृद्धीसाठी, मानवी श्रम कमी करण्यासाठी विविध साधनांच्या निर्मितीच्या माध्यमातून तंत्रज्ञानाचा वापर केला जातो.

वैज्ञानिक अभ्यास पद्धतीमध्ये प्रोफेसर जयंत नारळीकर या भारतीय संशोधकाने संशोधन पद्धती मध्ये प्रयोग, निरीक्षण व निष्कर्ष या प्रमुख टप्प्यांचा समावेश केला आहे.

- प्रयोग

वैज्ञानिक अभियानाची खऱ्या अर्थाने सुरुवात प्रयोगाने होते. यामध्ये समस्या किंवा संशोधनाची प्राथमिक माहितीचे संकलन आणि प्राथमिक अध्ययनाचा समावेश होतो. यानंतर प्राप्त माहितीला अनुसरून सारणीकरण विश्लेषण व विविध प्रयोग केले जातात. या प्रयोगांमध्ये तंत्रज्ञानाचा वापर करणे आवश्यक आहे तरच तो प्रयोग कृतिशील ठरतो.

- निरीक्षण

निरीक्षण म्हणजे प्राथमिक स्तरावर सक्रियपणे केलेले माहितीचे संकलन होय. उदाहरणार्थ विज्ञानामध्ये विविध संशोधने प्रयोगावर आधारित असतात या प्रयोगाचे निरीक्षणावरूनच सत्य शोधले जाते. उदाहरणार्थ कृषी संशोधन वेगवेगळ्या रोपांना वेगवेगळी खते देतो व या खतांचा रोपांवर काय परिणाम होतो याचे तो सातत्याने निरीक्षण करतो. त्याचे विश्लेषण केले जाते निष्कर्ष काढले जाते.

- निष्कर्ष

प्रयोग व निरीक्षणातील संकलनानंतर निष्कर्ष काढले जाते. निष्कर्षाला अनुसरून संशोधन कार्य पुढे केले जाते. निष्कर्ष जोपर्यंत सिद्ध होत नाही तोपर्यंत कल्पना परिकल्पना समस्येचे संभाव्य उत्तर असते.

उदाहरणार्थ आयझॅक न्यूटनच्या अगोदर अनेक लोकांनी सफरचंद झाडावरून जमिनीवर पडताना पाहिले, परंतु कोणीही कार्यकारण संबंध शोधण्याचा प्रयत्न केला नाही. न्यूटन यांनी पृथ्वीच्या गुरुत्वाकर्षणामुळे ही क्रिया घडते हे शोधले आणि हेच गृहीत पुढे न्यूटनचा 'गुरुत्वाकर्षणाचा नियम' म्हणून प्रसिद्ध झाला.

वैज्ञानिक अध्ययनाची खऱ्या अर्थाने सुरुवात प्रयोगातून होते यामध्ये समस्या किंवा संशोधन विषयाची प्राथमिक माहितीचे संकलन आणि प्राथमिक अध्ययनाचा समावेश होतो. यानंतर प्राप्त माहितीला अनुसरून विविध प्रयोग केले जातात. खुल्या वातावरणातील प्रयोग व बंदिस्त वातावरणातील प्रयोगांचा समावेश होतो. खुल्या वातावरणातील प्रयोगांवर संशोधनकर्त्याचे नियंत्रण असत नाही, तर बंदिस्त वातावरणातील प्रयोगांवर संशोधकाचे नियंत्रण असते.

उदाहरणार्थ, पर्जन्य निर्मितीला आवश्यक असलेल्या बाष्पीभवन व सांद्रीभवन क्रिया प्रयोगशाळेत विविध उपक्रमांच्या साहाय्याने नियंत्रित पद्धतीने अभ्यासता येतात, तर नदी कार्याचे संशोधन हे त्या प्रदेशात खुल्या वातावरणात जाऊन करावे लागते.

प्रयोग सातत्याने व वारंवार करावे लागतात, जोपर्यंत आपल्याला इच्छित निष्कर्ष येत नाही तोपर्यंत प्रयोग सुरू असतात विरोधकांची सत्यता तपासण्यासाठी प्रयोग केले जातात. प्रयोगामुळे समस्येशी संबंधित कार्यकारणभाव शोधण्यासाठी सूक्ष्मदृष्टी प्राप्त होते. संशोधनाचा स्तर व उद्दिष्टे यांच्यानुसार प्रयोगांमध्ये विविधता असू शकते. प्रयोग वारंवार किंवा पुन्हा पुन्हा करून निष्कर्ष काढला जातो. जो तार्किक विश्लेषण यावर आधारित असतो. शुद्ध शास्त्रातील व मानव्य शास्त्रातील प्रयोगांमध्ये खूपच भिन्नता असते. प्रयोगामुळे संशोधनाची विश्वासाहता वाढते म्हणूनच वैज्ञानिक संशोधन पद्धतीमध्ये प्रयोगाला खूपच महत्त्व आहे.

बंदिस्त प्रयोगशाळेत केलेले प्रयोग व वैयक्तिक संशोधन हे समाजातील प्रत्येक व्यक्तीला अनुभवता आले पाहिजेत. मानवाची पंचेंद्रिय (नाक, कान, डोळे, त्वचा, जीभ) हीच ज्ञानार्जनाची साधने आहेत. या ज्ञानेंद्रियांच्या मार्फत मानव बाह्य जगातील विज्ञानाचा अनुभव घेत असतो. एखादे वैज्ञानिक सत्य प्रयोगातून तपासून किंवा पडताळून पाहता आले तरच त्या सत्याची विज्ञान म्हणून गणना केली जाते. उदाहरणार्थ, वाहतुकीची साधने व उद्योगधंदे मानवाला सहजपणे अनुभवता येतील. ही वाहतुकीची साधने व उद्योगधंदे विज्ञानातून व तंत्रज्ञानाच्या माध्यमातून अस्तित्वात आलेली आहेत.

वैज्ञानिक प्रयोग व तंत्रज्ञानामुळे मानवाचा सामाजिक, आर्थिक, राजकीय व सांस्कृतिक जीवनात बदल घडविले

आहेत. विज्ञानाच्या प्रयोगामुळे औषध निर्मिती व शस्त्रक्रिया यांच्यामुळे आधुनिकता आली. सूक्ष्मदर्शकाच्या शोधानंतर विज्ञानाला नवी दिशा मिळाली. विविध लसींच्या प्रयोगांमुळे भयंकर आजारांचे निर्मूलन झाले. रोग विज्ञान व जंतुनाशक यांच्या संशोधनामुळे उपचार करणे सोपे झाले. विमान, रॉकेट यांच्या शोधाने विज्ञानाला नवी दिशा मिळाली. वैज्ञानिक प्रयोगातून हिवताप, क्षयरोग, प्लेग, पटकी, मलेरिया या सारख्या रोगांवर सुलभ इलाज उपलब्ध झाले. तसेच टेस्ट ट्यूब बेबी यासारखा अनोखा प्रयोग वैज्ञानिकांनी तंत्रज्ञानाचा वापर करून सत्यात उतरवला. तंत्रज्ञानाच्या वापरातून बंदुकीच्या दारूच्या शोधाने संरक्षण क्षेत्रात मोठी क्रांती घडवून आणली. येथूनच आधुनिक शस्त्रास्त्रे बनवण्यास सुरुवात झाली. वाफ, विद्युत व खनिज तेल यांच्या शोधाने विज्ञान व तंत्रज्ञानाच्या विकासाला वेग प्राप्त झाला.

Covid-19 यासारख्या महामारीच्या विरोधात तंत्रज्ञानाचे संबंधित तंत्रज्ञान क्षमतांचा आराखडा तयार करण्यासाठी 'कृती दलाची' स्थापना केली. या महामारीच्या विरोधात लढण्यासाठी तसेच त्यावरील उपाय योजनांसाठी भारत सरकार, विविध संस्था व शास्त्रज्ञ इत्यादी विज्ञान व तंत्रज्ञानाच्या माध्यमातून अथक प्रयत्न करत आहेत. covid-19 या आजारावर तातडीचे आणि लागू करता येण्याजोगे उपाय शोधण्यासाठी आपले वैज्ञानिक, आपले उद्योजक आणि आपल्या विविध संस्था ह्या विज्ञान व तंत्रज्ञानाच्या माध्यमातून जे प्रयत्न सुरू आहेत, त्या सर्वांची आपण प्रशंसा केली पाहिजे. त्यासाठी भारत सरकारने 'मेक इन इंडिया' कार्यक्रमाला अतिशय भक्कम पाठबळ दिले. त्यामुळे अनेक वैज्ञानिक संस्था आणि 'स्टार्टअप्स' ना covid-19 च्या चाचण्या, मास्क, पी-पीईकीट आणि व्हेंटिलेटर तयार करण्यासाठी प्रोत्साहन मिळाले. यामुळेच विज्ञान व तंत्रज्ञानाच्या माध्यमातून अर्थव्यवस्थेला चालना देण्यासाठी खऱ्या अर्थाने भारत पूर्णपणे सज्ज बनला.

या विधायक परिणाम बरोबरच काही विघातक परिणाम ही विज्ञानाने मानवाला दाखवून दिले आहे. यातील आण्विक व जैविक शास्त्राच्या प्रयोगामुळे संपूर्ण मानवी जीवन उद्ध्वस्त व नष्ट होऊ शकते. उदाहरणार्थ, हिरोशिमा व नागासाकी यासारख्या घटनांमधून मानवाने याचा अनुभव देखील घेतलेला आहे. विज्ञान व तंत्रज्ञान यामुळे युद्धखोर प्रवृत्तीचे सामर्थ्य वाढले आहे. विज्ञानाने 'यांत्रिकीकरण' घडवून आणले आहे. त्यामुळे मानवी श्रम कमी झाले, परंतु बेरोजगारी मोठ्या प्रमाणात वाढल्या. अमर्याद लोकसंख्या, कुपोषण, हिंसा व अत्याचार, मानसिक आजारपण, पर्यावरणातील प्रदूषण यासारख्या मानवी जीवन उद्ध्वस्त करणाऱ्या वाईट गोष्टीही मानवाला वैज्ञानिक प्रयोगामुळे अनुभवता येत आहेत. तसेच सातत्यपूर्ण प्रयोगामुळे प्रदूषणाची समस्या निर्माण झाली आहे. रासायनिक पदार्थांचे आक्रमण व शेती उत्पादनामधील प्रदूषण यांच्यामुळे अनेक आजार व रोग निर्माण झाले आहेत. त्याच्यामुळे मानव आजही हतबल आहे.

भारत सरकारने १९५८ मध्ये लोकसभेत 'विज्ञान धोरण' विषयक ठराव मंजूर होऊन देशातील संशोधन कार्याला एक प्रकारचे चालना दिली. या चालनेचे दृश्य स्वरूप म्हणजे महाराष्ट्रात 'विज्ञान व तंत्रज्ञान' कक्ष सुरू करण्यात आले. प्रत्येक घटक राज्यात अशा प्रकारचे कक्ष सुरू करण्यात येऊन सान्या देशाचीच वैज्ञानिक व तांत्रिक प्रगती वेगाने होऊ लागली. महाराष्ट्र राज्य हे राज्य विज्ञान व तंत्रज्ञान कक्ष स्थापनेत पहिला क्रमांक लागला. या कक्षानुसार राज्यातील विज्ञान व तंत्रज्ञानातील प्रकल्पांना योग्य त्या संशोधन संस्था, केंद्रे इत्यादी उपलब्ध करून देणे, राज्यात राबविल्या जाणाऱ्या विविध प्रकल्पांचे वैज्ञानिक मूल्यमापन करणे, सुसज्ज व साहित्य पूर्ण

प्रयोगशाळांची निर्मिती करणे, प्रयोग शाळांसाठी आवश्यक निधी उपलब्ध करून देणे ही या कक्षाची ध्येय होती. आधुनिक युगात भारत देश हा वैज्ञानिक प्रयोग व तंत्रज्ञानामध्ये सर्वात वेगवान व प्रगतशील असेल. लेझर तंत्र-ज्ञान, मूल पेशी, गुणसूत्रे, विश्वनिर्मितीचा महाविस्फोट याबाबत मानव पुढचे संशोधन करत आहेत. रसायनशास्त्र, भौतिकशास्त्र, जीवशास्त्र, वैद्यकशास्त्र, विद्युत शास्त्र, औषधनिर्माणशास्त्र, अंतराळ, सागरशास्त्र व अभियांत्रिकी अशा सर्व क्षेत्रात मानवाने असाधारण प्रगती केली असून भविष्यातही तो प्रगती करीत राहील. वैज्ञानिक तंत्रज्ञानाच्या साहाय्याने 'ग्रहताऱ्यांचे' संशोधन सुरू केले आहे. 'मार्स' हे यान मंगळावर पाठवले आहे. सूर्याच्या संशोधनासाठी 'पारकर' हे यान देखील अवकाशात रवाना झाले आहे. 'डॉली' मेंढीच्या स्वरूपात मानवाने पहिला प्रतिजीव किंवा क्लोन निर्माण केला आहे. वैज्ञानिक प्रयोगातून मानवाने तंत्रज्ञानाच्या साहाय्याने जनुकीय नकाशा तयार केला असून कृत्रिम मानव निर्मितीच्या दृष्टीने एक पाऊल पुढे टाकले आहे. थोडक्यात विज्ञान प्रयोगाचे आयोजन करताना तंत्रज्ञानाचा वापर करणे हे क्रमप्राप्त आहे. त्याच्या साहाय्याने विज्ञानामुळे अनेक फायदे होत असतात. मात्र, फायद्याबरोबरच विज्ञानामध्ये तंत्रज्ञानाचा वापर केल्याने धोके देखील निर्माण झाले आहेत. त्यामुळे आपली वसुंधराची सुद्धा तितकीच काळजी घेणे महत्वाचे आहे.

येणारी पिढी आहे प्यारी,
तर वसुंधरेला वाचवण्याची घ्या जिम्मेदारी"

Science Deficit – A Worrying Vogue Rampant

Ms. Moumita Mukherjee, New Horizon Public School, Panvel.

Introduction

It is said “We don’t grow when things are easy. We grow when we face challenges”. Covid-19 pandemic crisis has truly exposed the vulnerability and susceptibility of our education system in front of unprecedented challenges. The outbreak of the first wave had brought the entire education system to a standstill for months with physical institutions being abruptly closed and no alternate mode of disseminating knowledge to the students being known at that time. While educators across the globe grappled over the issue trying to figure out a feasible alternative, students lost the habit of daily going to school, exams got cancelled and most importantly learning got disrupted. Online classes emerged as the only solution – but was it truly a substitute? Could it actually replace the quality of learning that happened in the physical presence of a teacher? Could it truly ensure unadulterated attention of students especially with so many digital temptations all around? How could it replace the learnings that happened through practical experimentations? Was it not a veil to hide the actual learning loss that the students of this ‘Covid generation’ are getting exposed to?

This study is an attempt to understand the impact of this loss and the effectiveness of digital classes as a substitute by conducting a survey with the online educators as well as the students around Navi Mumbai.

Objectives

- To identify the lacunae as well as the benefits faced by both teachers and students in the online mode of teaching-learning process.
- To assess the difficulties in understanding and explaining a subject through digital mode from both student as well as teacher’s perspective.
- To estimate the learning loss (if any) caused by the pandemic especially

for an application- based and practical-based subject like science.

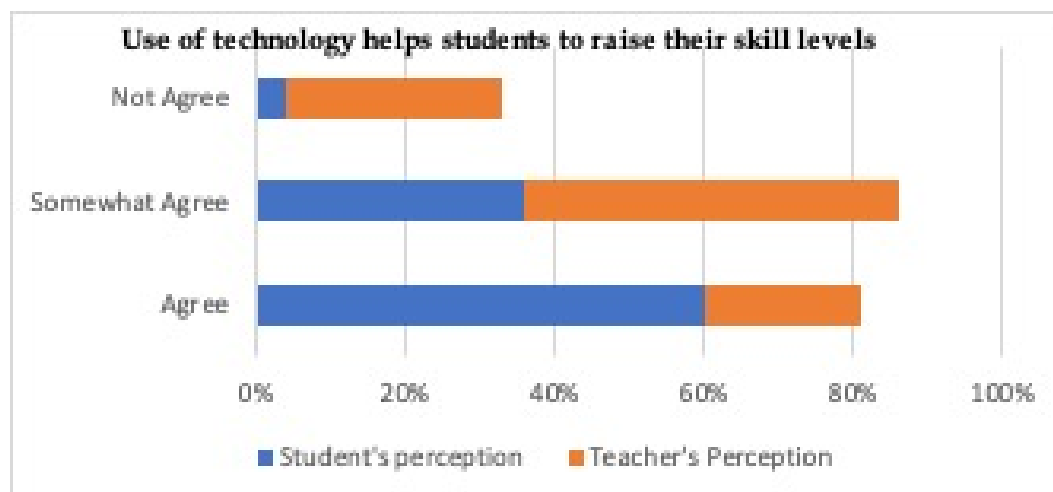
- To suggest and recommend possible measures to bridge the gap created so far.

Methodology

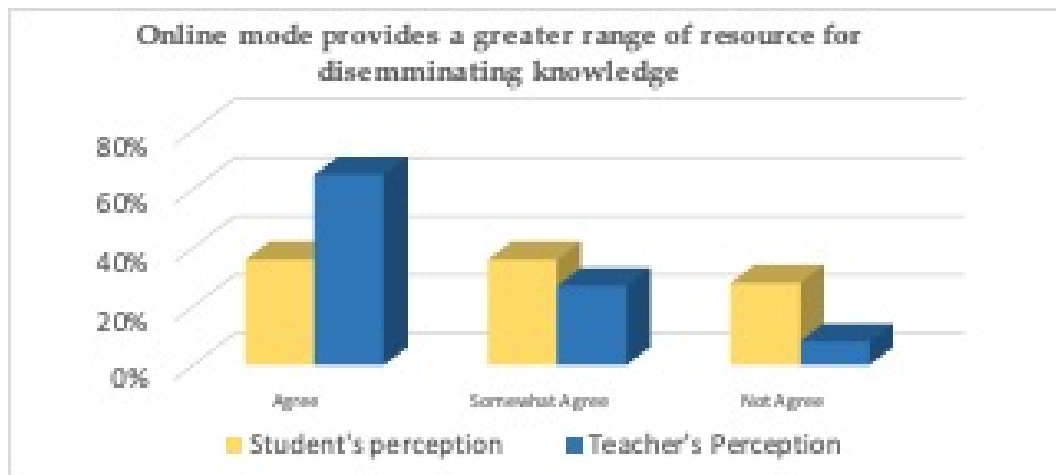
- A questionnaire covering various aspects was circulated separately to the teachers and students of secondary sections of different schools of Navi Mumbai and circulated through WhatsApp.
- Number of respondents: 113

Findings of the survey

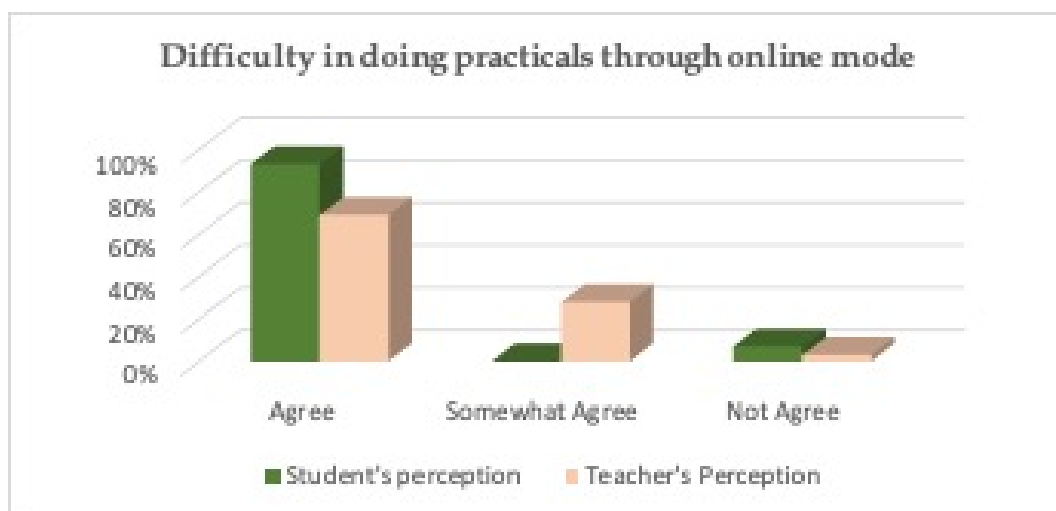
- The findings revealed that there was a significant divergence in the students' and teachers' perception on the various facets of digital learning.
- While 96% of the teachers perceived that the use of technology helped the students to raise their level of skills, only 78% of the students felt the same.



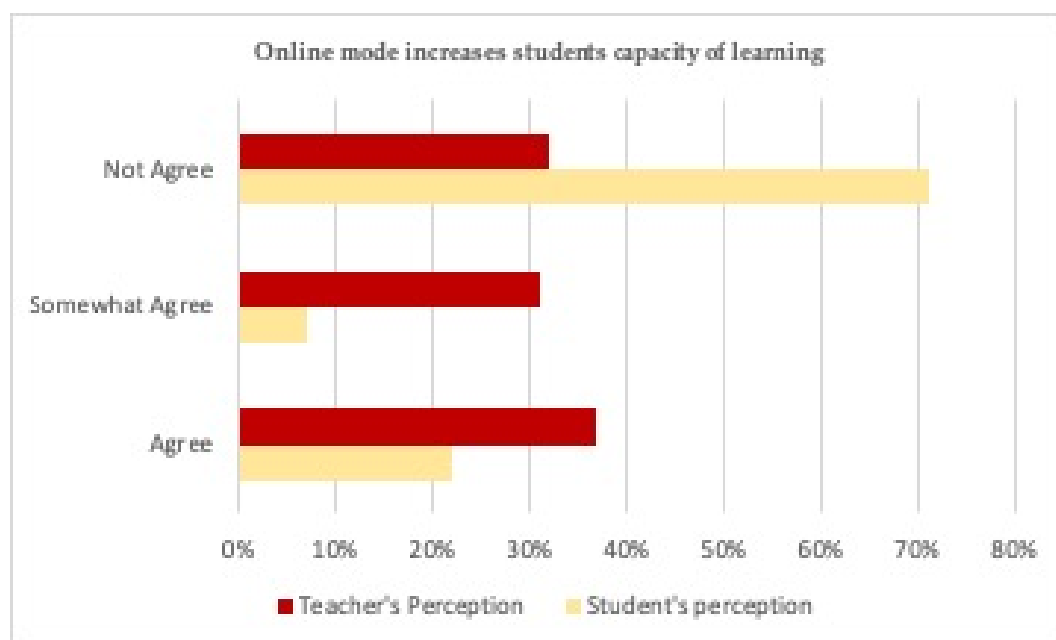
- 92% of the teachers felt that online mode gave them a chance to utilize a greater range of resources while taking their classes and thus make the dissemination of knowledge much more interesting. However only 65% of the students agreed.



- The students and teachers exhibited similar reservation about the challenges posed by the parent's lower level of digital literacy especially while monitoring their ward's academic progress. They exhibited similar concern on the health hazards caused by over exposure to internet, including social isolation.
- Compared to 69% teachers who strongly agreed that conducting practical experiments and making students understand through online mode was difficult, 93% of students strongly found such virtual experiments ineffective.



- 66% of the teachers perceived digital classes increased student's capacity of learning. Surprisingly just 29% of the students reciprocated similar perception.



- 96% of the teachers felt that while attending digital classes the students were more interested in witnessing the technology rather than grasping the content thereby leading to a learning gap.
- 98% of the teachers agreed that online classes increased the propensity of the students to cheat in examinations thereby raising apprehensions about the mode of evaluation in the digital environment. Interestingly nearly 100% of the students concurred with the teachers thereby substantiating the apprehension.

Conclusion

- The contrast in perception among the teachers and students regarding digital classes seems to raise a serious question on the efficacy of online mode as an instrument of learning especially from the student's perspective. While the students' perception may be slightly biased given the boredom of social isolation, it surely indicates that digital classes are dampening their motivation to learn.
- Classroom sessions and physical interactions are perceived to be much better environment for learning especially without any distraction. This is even more true for application-based subjects like science wherein practical experiments in the physical laboratory is truly irreplaceable.

- However, the advantages of technology especially in disseminating information in an interesting manner cannot be disregarded altogether.
- With the commencement of physical classes, a blend of the old authentic way of taking classes (chalk duster/ real labs) along with new-age presentations, AV materials will enhance the understanding and make the learning enjoyable.

कोरोना महामारीच्या काळात विद्यार्थ्यांच्या विज्ञान व गणित अध्ययनात झा- लेले नुकसान

सौ. राजेश्री प्रमोद नेहेते, न. मुं. मनपा शा. क्र. 20, तुर्भे गाव

कोटून आला हा इवलासा जीव,
हाहाकारले संपूर्ण हे जग,
माणसाला माणसापासून तोडून,
थांबले हे संपूर्ण जग.

कोरोना महामारीने मार्च 2020 मध्ये आपल्या देशात पहिले पाऊल टाकले. पाहता पाहता घड्याळाच्या का-
ट्यावर धावणारे संपूर्ण जग क्षणार्धात थांबले. सर्वत्र संचार बंदीचे वारे वाहू लागले. काम बंद, दुकाने बंद, कंपन्या
बंद अहो एवढेच काय तर शाळा- शिक्षण सुद्धा बंद झाले.

या महामारीत जनतेचे प्राण वाचवण्यासाठी सरकारने संचारबंदी, टाळेबंदी चा पर्याय निवडला. परंतु या आलेल्या
टाळेबंदी मुळे अनेक प्रश्न निर्माण झाले. यातून शिक्षण क्षेत्रावर या संकटाचा सर्वात जास्त परिणाम झाला असे
म्हटल्यास वावगे ठरणार नाही. या कालावधीत झालेले शैक्षणिक नुकसान कसे भरून काढता येईल त्यावर चर्चा
झाली व त्यातूनच शाळा बंद पण शिक्षण सुरु ठेवायचे तर त्यासाठी ऑनलाइन शिक्षण हा पर्याय प्रामुख्याने पुढे
आला. कारण विद्यार्थ्यांचा विचार करताना शिक्षण व सुरक्षितता या दोन्ही बाबींवर विचार करणे गरजेचे होते.
म्हणून त्यासाठी विविध माध्यमांद्वारे विद्यार्थ्यांपर्यंत कसे पोहोचता येईल? विद्यार्थी शाळेत येऊ शकत नाही तर
शिक्षण त्यांच्यापर्यंत जाऊ शकते का? त्यासाठी काय करावे लागेल? यादृष्टीने विचारचक्र सुरु झाले. त्यातूनच
पुढील उपक्रमांद्वारे विद्यार्थ्यांपर्यंत पोहोचण्याचा प्रयत्न केला जात आहे.

- | | |
|---------------------------|----------------------|
| • शाळा बंद पण शिक्षण सुरु | • गोष्टीचा शनिवार |
| • टिली मिली | • ऑनलाईन स्वाध्याय |
| • दीक्षा ॲप | • यु-ट्युब |
| • ई-लायब्ररी | • स्वाध्याय पुस्तिका |
| • झूम मीटिंग | • गुगल मीट |
| • विज्ञानाचा गुरुवार | • गृहभेटी |

प्राथमिक शिक्षण म्हणजे शैक्षणिक स्तंभाचा पाया मानला जातो. हा पायाच कच्चा राहिला तर त्यावर उभी राहणारी
शैक्षणिक विकासाची इमारत कशी तग धरू शकेल? असेच आज सर्वांना वाटते आहे या विचाराचे कारण म्हणजे
आज आपण तात्पुरती का होईना पण निवडलेली ऑनलाईन शिक्षण पद्धती.

शिक्षक रोज विद्यार्थ्यांना ऑनलाईन तासिका घेऊन शिक्षण देण्याचा प्रयत्न करीत आहेत. परंतु हे वाटते तितके सोपे नाही. कारण जागतिक व देशाच्या अर्थव्यवस्था लॉकडाऊनमुळे मंदी, बेरोजगारीच्या चक्रात अडकल्यामुळे डळमळीत होत आहेत. ठप्प झालेल्या अर्थव्यवस्थेमुळे हातावर पोट असणाऱ्या कष्टकऱ्यांचे तांडे शहराकडून गावाकडे निघाले. उपासमारीने मरायचे की कोरोना ने या पेचात हा कष्टकरी वर्ग अडकला. अशा परिस्थितीत यांना ऑनलाईन साहित्य मिळवणे शक्य आहे का? असा प्रश्न निर्माण होतो.

'युनेस्को' च्या अहवालानुसार भारतात 15 लाख शाळा बंद आहेत व त्यामुळे 26 कोटी विद्यार्थी शिक्षणापासून वंचित आहेत तर उच्च शिक्षणात 50 हजार शिक्षण संस्था बंद आहेत व त्यातील 3.70 कोटी विद्यार्थी घरी बसले आहेत. एकूणच काय तर कोरोनाची समस्या ही फक्त आरोग्याची समस्या नसून या संकटाला शैक्षणिक समस्यांची बाजूदेखील आहे.

काळाची गरज ओळखून शिक्षकांनी तंत्रज्ञानाचा वापर कसा करावा याचे ज्ञान अवगत केले. शिक्षक निरंतर चांगल्यात चांगल्या प्रकारे सहज विद्यार्थ्यांपर्यंत शिक्षण कसे पोहोचवता येईल यासाठी धडपड करत आहेत. व्हाट्सअप वरून पीडीएफ पाठवणे, युट्युब वर व्हिडिओ पाठवणे, झूम मीटिंग घेणे, ऑनलाईन प्रश्न पत्रिका देणे, प्रसंगी झेरॉक्स करून प्रश्नपत्रिका मुलांपर्यंत पोहोचवणे, गृहभेटी देणे, गुगल मीट चा वापर करून शिकवणे, विविध ऑनलाईन स्पर्धा घेणे.

परंतु प्रत्यक्ष वर्गात बसून घेतले जाणारे शिक्षण व ऑनलाईन शिक्षण या खूप मोठा फरक आहे. "शिक्षण हे एकमेव उन्नतीचे साधन आहे." असे महामानव डॉ. बाबासाहेब आंबेडकर म्हणतात. परंतु 'कोरोना' या जागतिक संकटामुळे शिक्षण क्षेत्रात मोठी अस्वस्थता निर्माण झाली आहे.

आई-बापाचं ऐकत नाही

अभ्यासाला बसतच नाही

आकडेमोड आठवत नाही

वाचनात देखील गती नाही

मुलांचे लक्ष एकाच गोष्टीकडे गुंतवणे ही महाकठीण गोष्ट आहे. शाळेत निदान मित्र, शिक्षक, शाळेचे वातावरण या कारणांमुळे तरी मुले अभ्यासाकडे लक्ष देतात. घरात मात्र या वातावरणाचा अभाव असतो.

ऑफलाईन शिक्षणातून विद्यार्थ्यांच्या व्यक्तिमत्त्वाचा विकास होत होता. शाळेत मुले पारंपारिक शिक्षणासोबत सामाजिक वर्तन सुद्धा शिकत असतात. कोणत्याही व्यक्तीच्या जडणघडणीमध्ये तो जिथे शिकतो तिथल्या वातावरणाचा, संगतीचा अत्यंत महत्त्वाचा वाटा असतो. क्रीडा स्पर्धांमुळे शारीरिक व मानसिक विकास होत होता. विविध परीक्षांमुळे विद्यार्थ्यांची बौद्धिक क्षमता समजून घेत होती. त्यांच्यातील आत्मविश्वास वाढीस लागून शिक्षणाची व वाचनाची ओढ निर्माण होत होती.

ऑनलाईन शिक्षण पद्धतीमध्ये समवयस्क मित्रांमध्ये गटाने राहणे, मैदानात खेळणे, दंगामस्ती करणे या गोष्टी घडत नाहीत. त्यामुळे त्यातून आपोआप मिळणारे सामाजिक वर्तनाचे नियम, सामाजिक शिस्त ऑनलाईन शिक्षणातून देता येत नाही.

विज्ञान व गणित या विषयांना आपल्या जीवनात खूप महत्त्वाचे स्थान आहे. दैनंदिन व्यवहारात ज्याप्रमाणे

गणित महत्वाचे आहे तितकेच महत्वाचे स्थान विज्ञानाला आपल्या जीवनात आहे. आपल्या भोवताली घडणाऱ्या गोष्टींकडे बघताना आपण त्यांचा वैज्ञानिक दृष्टीने विचार करतो, कारणे शोधतो, पडताळून पाहतो व हे सर्व विज्ञानाच्या अभ्यासाने शक्य होते.

एकदा आईन्स्टाईन यांना एक प्रश्न विचारला की तुम्ही काय काम केले आहे? तेव्हा ते उत्तर देतात की "तुम्ही भूतकाळातून शिका, आज मध्ये जगा आणि उद्यासाठी आशावादी राहा, तर्कशीलता सोडू नका." हा आशावाद आपण विज्ञानाच्या मदतीशिवाय विद्यार्थ्यांमध्ये रुजू शकत नाही. गणिता शिवाय विज्ञान पूर्ण होऊ शकत नाही आणि विज्ञान या शिवाय गणित पूर्ण होऊ शकत नाही. गणिता विषयी बोलताना गणितज्ञ टोबियास डॉटजिज म्हणतात, " गणित हा सर्वोच्च न्यायाधीशासारखा आहे, त्याने काढलेले निष्कर्ष, उत्तर यावर तोड नसते. तोच निर्णय अंतिम असतो." यामुळे असे म्हणता येईल की गणित आणि विज्ञान शिवाय आपल्या पुढील पिढीचे शिक्षण हे अपूर्णच राहील.

बदलत्या काळाप्रमाणे विद्यार्थ्यांना गुणवत्तापूर्ण शिक्षण मिळणे हा त्यांचा मूलभूत अधिकार आहे. कारण चांगल्या शिक्षणाच्या बळावरच योग्य करिअर निवडले जाऊ शकते. कोणत्याही देशाला विकसित करण्यासाठी शिक्षणाचा, गणित, विज्ञान, तंत्रज्ञानाचा खूप मोठा वाटा आहे.

शालेय शिक्षणात काही उपक्रम प्रत्यक्ष उपस्थित राहून आणि शिक्षकांच्या देखरेखीखालीच करावे लागतात. प्रयोग शाळेत केलेले प्रयोग हे त्याचे ठळक उदाहरण आहे. अशा प्रकारे प्रयोगशाळेतून दिले जाणारे शिक्षण ऑनलाइन माध्यमातून देता येणे अत्यंत अवघड आहे व ते जरी देण्याचा प्रयत्न केला तरी ते विद्यार्थ्यांपर्यंत पोहोचत नाही. "ट्राय" च्या अहवालानुसार भारतात 2020 मध्ये 52 टक्के जनता इंटरनेटचा वापर करते. म्हणजे निम्मा भारत इंटरनेटच्या लाभापासून वंचित आहे. तरी मग ऑनलाइन शिक्षण कसे होणार हा प्रश्न पुन्हा तसाच राहतो.

हो शाळा बंद, वर्ग बंद,
शिकवणही बंद झालं,
अनुभवही घेणे बंद झालं,
विज्ञान अन गणिताचं
मोठच नुकसान झालं.

शाळेत प्रत्यक्ष गणित व विज्ञानाचे अध्यापन करताना शिक्षक मोठ्या प्रमाणावर शैक्षणिक साहित्याचा वापर करतात. विद्यार्थ्यांना साहित्य प्रत्यक्ष हाताळता येते. अनुभव घेता येतो व अनुभवातून मिळणारे शिक्षण चिरकाल टिकणारी असते. असे शिक्षण ऑनलाइन मधून देता येत नाही. मुलांच्या संकल्पना तितक्या दूर होत नाहीत. प्रात्यक्षिक वेळेस तासनतास प्रयोगशाळेत उभे राहून नवीन नवीन प्रयोग करत विद्यार्थी हा विज्ञानाची कास धरत असतो. विज्ञानाविषयी निष्ठा व विज्ञानवादी विचार त्याच्या मनावर रुजत असतात. हे ऑनलाइन शिक्षणामध्ये शक्य नाही. लहानपणापासूनच गणित व विज्ञान हे विषय समोर बसून समजून शिकण्याची सवय असते. ही परंपरागत पद्धत अचानक बदलणे मुलांच्या अंगवळणी पडत नाही. म्हणून त्यांचे ऑनलाइन वर्गात अवधान कमी होते. ऑनलाइन वर्गात अथक प्रयत्न करूनही गणित-विज्ञान विषय पाहिजे तितक्या व्यवस्थितरित्या मुलांपर्यंत पोहोचत नाही.

विज्ञान हे प्रात्यक्षिकाने समजणे सहज सोपे असते. प्रात्यक्षिकांच्या माध्यमातून आपण सहजतेने विज्ञानाच्या गोष्टी, संकल्पना विद्यार्थ्यांना समजावून देतो व त्यांना त्या समजतात देखील. त्यामुळे त्यांना त्या गोष्टी पाठ करण्याची गरज पडत नाही. पण ऑनलाईन मध्ये प्रात्यक्षिकच सर्वच घेता येत नाही. यात विद्यार्थ्यांना प्रयोगशाळेत नेता येत नाही. प्रत्यक्ष अनुभव मिळत नाही म्हणून त्यांचे संबोध स्पष्ट होत नाहीत. अशा प्रकारे प्रयोगशाळेतून दिले जाणारे शिक्षण ऑनलाईन माध्यमातून देता येणे अत्यंत अवघड असते.

विज्ञान विषयातील बराचसा भाग हा कृतीद्वारे स्पष्ट करावा लागतो. आकृत्या मुलांना काढता येणे, समजणे खूप महत्वाचे असते. परंतु ऑनलाईन शिक्षणात ते तेवढ्या प्रभावीपणे समजत नाही.

प्रत्यक्ष वर्गात एखादी गोष्ट समजली नाही तर विद्यार्थी लगेच शिक्षकांना किंवा आपल्या वर्ग मित्राला विचारून समजून घेता. बऱ्याच मुलांना वर्गमित्रांनी सांगितलेले चटकन समजते परंतु ऑनलाईन शिक्षणा त्याला मर्यादा येतात. मुले आपल्या अडचणी सांगू शकत नाही, भावना व्यक्त करू शकत नाहीत. त्यामुळे ती एकच कोंडी होत आहेत. शारीरिक, मानसिक, बौद्धिक, भावनिक सर्वच विकासांवर ? निर्माण झाले आहे प्रश्नचिन्ह निर्माण झाले आहे.

ऑफलाईन वर्गात शिक्षक व विद्यार्थी समोरासमोर असतात. तेव्हा शिक्षकाला संपूर्ण वर्गाला आपल्या नजरेच्या कवेत घेता येते. विद्यार्थ्यांच्या चेहऱ्याचे हावभाव वाचून तो समजू शकतो की त्यांना त्याचे बोलले कळते आहे की नाही.

बऱ्याच विद्यार्थ्यांची आर्थिक परिस्थिती बेताची असल्यामुळे त्यांना ऑनलाईन शिक्षणात सहभाग घेता येत नाही. आधीच दोन वर्षांपासून शिक्षण बंद, सुरु झाले तर तेही ऑनलाईन अशातच विद्यार्थी गणित व विज्ञान या दोन्ही विषयात जास्त मागे पडली. कारण या विषयांचा महत्वाचा घटक म्हणजे सातत्य व सराव व या दोन्ही गोष्टी पूर्णपणे बंद होत्या. त्यामुळे आज शहरी भागापेक्षा ग्रामीण भागातील विद्यार्थ्यांना गणित व विज्ञान या विषयांचे पायाभूत ज्ञान पूर्णपणे त्यांच्या स्मृती पटलावरून पुसले गेले आहे.

गणित व विज्ञान विषयाच्या बळावरच विद्यार्थी तांत्रिक ज्ञान मिळू शकतो. वैज्ञानिक ज्ञान प्रयोगातून अनुभवातून तो मिळवत असतो. पण आता शाळा बंद असल्यामुळे गणित व विज्ञान विषयाची त्याची ग्रहणक्षमताच पूर्णपणे कमी झालेली आहे.

ऑफलाईन वर्गात त्यांचे कच्चे दुवे हेरून आधी शिक्षकांना ते स्पष्ट करावे लागतील. जोशी क्षणाचा आनंद वर्गात बसून मिळतो, तो घरी बसून मिळत नाही. वर्गात विद्यार्थ्यांच्या क्षमतेनुसार गट करून गटाने त्यांचा अभ्यास घेता येतो. त्यामुळे त्यांना विषयाची, अभ्यासाची पर्यायाने शिक्षणाची आवड निर्माण होते. परंतु ऑनलाईन अध्यापनात वर्गात ते शक्य होत नाही. त्यामुळे एक-दोन घटक समजले नाही तर न्यूनगंडाची भावना निर्माण होऊ शकते.

ऑफलाईन वर्गात आपल्या समोर शिक्षक शिकवतात. आपले संपूर्ण लक्ष त्यांच्याकडे असते. ऑनलाईन वर्गात समोरासमोर नसल्यामुळे कंटाळा येऊ शकतो.

गणित हा विषय पूर्णतः सरावावर अवलंबून आहे. म्हणून विद्यार्थ्यांनी दिलेला गृहपाठ करणे, जास्तीत जास्त उदाहरणे सोडविण्याचा सराव करणे गरजेचे असते. परंतु शिक्षक समोर नाही, त्यामुळे शिक्षकांचा धाक राहत

नाही व उदाहरणे सोडवलेली जात नाहीत. पर्यायाने अशी मुले हळूहळू मागे पडत जातात.

नेटवर्क प्रॉब्लेम मुळे मधेच ऐकू न येणे, फळा न दिसणे यामुळे त्यांना विषय नीट समजत नाही व त्यामुळे त्यांना ऑनलाइन शिक्षण व पर्यायाने हे कठीण व महत्वाचे विषय अधिकच कठीण वाटतात.

वर्गात एखादे मॉडेल घेऊन आपण त्यांना स्पष्टीकरण देतो. विद्यार्थी प्रत्यक्ष ते मॉडेल हाताळतात, निरीक्षण करतात, त्यांना पडलेले प्रश्न विचारतात, विषय समजून घेतात. त्यामुळे तो घटक विद्यार्थ्यांच्या अधिक लक्षात राहतो. त्यांना आवड निर्माण होते. आत्मविश्वास वाढतो. परंतु ऑनलाईन शिक्षणात हे शक्य होत नाही. त्यामुळे त्यांचा या विषयातील रस कमी होतो. संकल्पना, संबोध नीट समजत नाही व कठीण विषय अधिकच पटवून होऊन जातो.

गणित विषयाचा आपण विचार करतो तेव्हा गणित हा सरावाचा विषय आहे. परंतु या कोरोना काळात नेमके तेच झाले नाही. सराव व सातत्य दोन्ही कमी पडले व मुले थोडी का होईना मागे पडली.

गणित विषयात प्रत्येक गणित योग्य त्या पायरीने सोडवायचे असते. एखादी पायरी विद्यार्थ्यांना समजली नाही तर प्रत्यक्ष वर्गात ते लगेच शिक्षकांना विचारून आपल्या शंकेचे निरसन करतात. तो भाग समजून घेतात. कधी-कधी आपण प्रत्यक्ष विद्यार्थ्यांना फळ्यावर गणिते सोडवण्यास सांगतो. त्यामुळे त्यांच्यातील आत्मविश्वास वाढतो. त्यांना प्रत्यक्ष कृती केल्याचा आनंद मिळतो. ऑनलाइन शिक्षणामध्ये असे होत नाही. त्यांचे अवधान टिकून राहत नाही व तो घटक नीट समजत नाही. कारण इ. पहिली ते आठवी च्या विद्यार्थ्यांचा वयोगट असा आहे की अवधान टिकवणे हे फार जिकीरीचे काम आहे. ही मुले चंचल असतात व त्यांचे अवधान हे प्रत्यक्ष वर्ग अध्यापनातच टिकू शकते.

प्रत्यक्ष वर्गात गणित विज्ञान अध्यापन करताना आपण प्रत्येक विद्यार्थ्यांपर्यंत पोहोचतो. त्यांच्याजवळ जाऊन त्यांच्या शंकांचे निरसन करतो. गणितात भौमितिक रचना करताना आपण प्रत्यक्ष प्रत्येक मुलांपर्यंत पोहोचून तो घटक त्यांच्याकडून घटवून घेतो. विज्ञानात आकृती काढताना त्यांना आपण वैयक्तिक मार्गदर्शन करतो व त्यामुळे त्यांच्यातील कौशल्य विकसित होते. त्यांना निर्मितीचा आनंद मिळतो. त्या आनंदाची उत्साही वातावरणात शिक्षण होते परंतु ऑनलाईन शिक्षणात या सर्व गोष्टी घडून येत नाहीत.

प्रत्यक्ष वर्गात पाच तास विद्यार्थी आपल्या जवळ असतात. त्यामुळे आकडेमोड करणे, पाढे पाठ करणे, प्रात्यक्षिक घेणे, अधिक माहिती पुरवणे हे शक्य होते. परंतु ऑनलाईन शिक्षणात तेवढा वेळ मिळत नाही.

शिक्षणात तंत्रज्ञानाचा वापर वाढला. विद्यार्थ्यांना अनेक गोष्टी शिकायला मिळाल्या परंतु प्रत्यक्ष अध्ययन-अध्यापन प्रक्रिया, समोरा समोर घडणाऱ्या शिक्षक-विद्यार्थी आंतरक्रिया, विचारांचा विस्तार, संकल्पना स्पष्ट होणे, समजणे, घटक समजून सोडवणे, प्रत्यक्ष सहभाग घेणे, त्या गोष्टी हाताळणे यांचा अभाव निर्माण झाला व शिक्षण प्रक्रियेत समस्या निर्माण झाल्या. सुसूत्रता विस्कळीत झाली. याचा परिणाम विद्यार्थ्यांच्या गुणवत्तेवर झाला. विकासावर झाला. ऑनलाइन शिक्षणामुळे त्यांना हातात मोबाईल मिळू लागला व अनेक हुशार मुले गरजेपेक्षा जास्त काळ मोबाईल वरील गेम्स च्या आहारी गेली. भरकटलेली दिसायला लागली.

त्यामुळे गणित विज्ञानच काय पण त्यांच्या सर्वांगीण प्रगतीसाठी आवश्यक अशा खेळ, गाणी, गोष्टी, गप्पा, मित्र या गोष्टी ते कुठेतरी हरवून बसले व याचा परिणाम त्यांच्या मानसिक, शारीरिक, सांस्कृतिक, सामाजिक सगळ्याच

बाबतीत होत आहे. ते भावनाशून्य, एकलकोंडे होताना दिसत आहेत व हे दृश्य अत्यंत विदारक व घातक आहे. यासाठी ऑनलाईन शिक्षण हा एकच पर्याय न ठेवता विविध पर्याय आपण शोधले पाहिजे. विद्यार्थ्यांना तशा संधी उपलब्ध करून दिल्या पाहिजेत. विद्यार्थी ऑनलाईन शिक्षणाचा कंटाळा करतात असे वाटत असल्यास पालकांनी यासाठी आपला थोडा वेळ आपल्या मुलांसाठी खर्ची घालणे गरजेचे आहे. ऑनलाईन तासाच्या वेळी मुलांजवळ पालक बसले तर मुले गेम्स कडे कमी वळतील असे मला वाटते.

ऑनलाईन शिक्षणात नेटवर्क व रिचार्ज या मोठ्या समस्या आहेत. त्यासाठी त्यावर उपाययोजना म्हणून व सर्व विद्यार्थ्यांना शिक्षणाच्या प्रवाहात आणण्यासाठी आमच्या नवी मुंबई महानगरपालिकेच्या प्रत्येक विद्यार्थ्यांच्या खात्यावर महानगरपालिकेने रिचार्ज साठी हजार रुपये दिले. त्यामुळे ही समस्या सुटली.

कोरोनाने काय केलं हे बघतानाच कोरोना सोबत जगणं शिकण्याचा आता हा काळ आलेला आहे असे मला वाटते. या काळात व्यायाम, झोप, रोगप्रतिकारक शक्ती वाढवणारा आहार, आरोग्यविषयक चांगल्या सवयी यांचे महत्त्व आपण विद्यार्थ्यांना पटवून दिले पाहिजे व ते हे सर्व अमलात आणत आहेत की नाही हे आपण पाहिले पाहिजे.

चार भिंतींच्या आतील शिक्षण बिनभिंतींच्या शाळेत देण्याची ही उत्तम संधी आहे व याचा आपण विचार केला पाहिजे. या परिस्थितीत नवीन पर्याय शोधणे, दुःखाला घाबरून न जाता त्याच्याशी दोन हात करण्याची ताकद आपण ठेवावी.

सर्वांनी एका प्रवाहात येण्यासाठी व आता मोकळा श्वास घेण्यासाठी शेवटी एवढेच म्हणून

‘लवकर कोरोनाचे संकट दूर होऊ दे,
पूर्वीचे दिवस पुन्हा अनुभवू दे,
पुन्हा मोकळा श्वास घेऊ दे,
पुन्हा एकदा उंच भरारी घेऊ दे,
स्थिरावलेले, थांबलेले जग पुन्हा वेगवान धावू दे,
माणसाला पुन्हा माणसात राहून जगू दे.”

Online mode — a challenge for students and teachers

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Introduction

The COVID pandemic began in December 2019. In India, by February 2020, the situation forced all academic institutions to close down. These institutions immediately started gauging the technical challenges, explored the required online platforms suitable for their system and trained the teachers.

The pandemic situation was globally known to many IB curriculum schools before it was experienced by other schools in India. They, therefore, were already on the forefront in gauging the abovementioned technical difficulties and exploring the usage of online platforms.

By the end of April 2020, majority of academic communities and institutions started using the online platforms for their curriculum. This online education system compelled the schools to shift their methods of conducting the examinations in the online mode. These radical changes of academic exchange as well as evaluation systems resulted in positive as well as negative effects on students' learning. One of the authors being a teacher in a reputed IB curriculum school, got an opportunity to work with the students during these trying times both in online and offline mode. The paper is a result of the teacher's interaction with the students.

The sample size for the study consisted of 38 physics students from grade XII. The study was conducted in the form of a questionnaire which was given to the students through Google forms. Their google form responses were analyzed. Separate zoom meetings were held to conduct interviews of some of the students to probe their responses further. We describe the prominent effects that emerged from these interactions.

Positive effects of online mode of learning

- Safety of student and teacher communities

The pandemic has posed serious health risks to the vulnerable age groups in the society i.e. the elderly people and children. In accordance with the government directives, schools have taken a major step of avoiding physical contact and the risk of spreading by making most of its teaching operations online. This step has ensured safety, physical and mental well-being of student, parents and teacher communities. Schools also realized the importance of physical and mental fitness of students and thus started including special sessions on yoga, fitness and creative sessions.

- Increased use of different simulations and videos for better understanding the concepts

The online mode of teaching did not compensate for the physical interaction between a student and teacher. This lacked the motivation for the students and resulted in a decrease in student engagement in the class, at times even affecting attendance. In order to make the teaching and learning process more effective, observable and engaging, the teachers, therefore, had to come up with different teaching strategies. This involved the use of different methods like power point presentations with animations, simulations and videos to explain the concepts and thus reducing the burden of imagination of concepts on students' mind. Though these tools have always been recommended for effective teaching even before the pandemic, their significance and usage as teaching tools has increased drastically in these times.

- Use of virtual laboratories

One of the main challenges for the schools was to find alternatives for laboratories. Though virtual platforms ensured that the classes could be conducted regularly it was not easy to replicate the laboratory atmosphere through the online mode. Teachers have been making use of virtual labs as an alternative to compensate for this loss. Virtual

labs make use of photographs and videos of the experiments. Some of the virtual labs enable performing simulation experiments and activities. All of these virtual labs are equipped with reader-friendly set of instructions which can be easily followed by students and teachers alike. These labs provide observation tables which help students in organizing their data in a proper format. They also provide some enquiry-based questions which can help students connect the theoretical knowledge with their experimental data analysis.

Negative effects of online mode of learning

- Increased screen time

Though the online mode facilitated teaching and learning process, it also meant longer screen time for students. Even with the class timings slightly reduced, students are expected to be attending all the classes, seated in the same position for hours at a stretch. They are expected to keep their videos on and attend all sessions with same enthusiasm and concentration levels. This continuous sitting and exposure to screen did cause a great amount of stress and fatigue among the students.

- Lack of peer learning

As students are not able to meet their peers, they feel as if they miss out all the physical activity and interaction which they enjoy. We could gauge it from their responses which are mentioned below.

S: "...you get to meet friends and teachers in person (in offline mode)..."

S: "...there is also a lot of physical activity and interaction in between two classes which is more enjoyable...it is missing in online..."

- Lack of personalized motivation system

Students often require mental/emotional help for some personal issues and they tend to look for support outside their homes. Some of these problems may be the adolescence age related issues or some personal loss on the home front due to the present pandemic.

Some students have lost very close family members in this pandemic. School friends and teachers have immense importance in providing

emotional support to the students in such times. However due to lack of physical interaction, such students have been deprived of this support and they tend to withdraw themselves from everyone. This withdrawal and lack of support with the added personal grief, may at times change the outlook of students towards life. We did come across one such student in our sample. The student used to perform well in class and every teacher had high expectations from him. Sadly, the student lost many of the closest people in the pandemic and was quite depressed due to it. The student kept this grief to himself and portrayed around a smiling, fun making casual picture of himself to everyone. This grief did affect the student's outlook towards his studies as he became very casual even about important submissions and deadlines. It was at this time that student was provided some support from one of his teachers and that did affect him partially as there was some change in his attitude from there on.

Some students from the sample claimed that attending school, though might be boring at times, but the students are expected to move around and behave in a particular manner, follow a set of accepted guidelines and rules which instills discipline in them.

S: "...there is a sense of self-discipline when we are present in school and follow the school timetable. At home there is no such hard and fast routine which we are required to follow..."

Some of the students were of the opinion that they are not able to replicate the same dedicated working timetable and environment at home which brings about a casual attitude in them and tends to delay in their school work submissions.

S: "...more (focused) work can be done by staying in school (as you have focused time allotted for it)."

- Monotonous online routine

Students claim that continuous long-term stretch of secluded online learning tends to make monotonous and boring routine. In physical school, even minor moments in between two classes like a small chat

with friends, playing and running in the corridors while switching classes, discussing pending doubts with the teachers, taking feedback, etc. (moments which cannot be predicted) are refreshing and are equally enjoyable.

S: "...online is monotonous routine... in offline you have a lot of unpredictable additions like... what will be the discussions about, what will anyone say, what will we do today, etc...are more fun..."

- Difficulty in gauging the extent of learning that has taken place in students

This is a disadvantage of online learning which is mostly shared by the teachers. Students tend to keep their videos off frequently in online learning. The teachers are then left clueless about the extent to which the students have understood which otherwise could be gauged from the students' facial expressions and body language in physical classes.

- Nonresponsive behavior

In classes, teachers often ask questions to gauge the learning of the student or to check the attentiveness of the student. In online classes, students often do not respond verbally to the questions asked by the teachers. They do not ask doubts or interact with the teachers.

We received an interesting and frank explanation from some of the students in the sample with this regard.

S: "...in offline you are bound and restricted in class with no chance of moving out... when asked to interact, you have no chance of avoiding. In online you have the option of staying muted...you have that freedom of staying muted and not responding."

- Distractions

Majority of the students from the sample confessed that while attending classes online they are tempted to look at their mobile chats and get distracted from the lesson. This leads to discontinuity in the flow of their understanding as they lose focus repeatedly. Such repeated distractions and lack of attention makes the lesson too boring.

S: "...in online there are more temptations towards phone and more chances of you getting distracted from the lesson being taught. In offline, less chances of distraction and less temptation. Even if you get distracted it won't be for too long as you know you cannot afford to get distracted. You stay focused."

Conclusion

The forced online mode of education, though ensures safety of students as well as teachers, it hampers the necessary conditions required to make teaching-learning process productive. During a small duration in the year 2021 when schools were opened, and classes were conducted in physical mode, we observed that the students and the teachers could enjoy their interactions after a long gap of 1.5 years. These interactions made them prominently aware about the importance of health and fitness, the use of different ICT tools, effects due to lack of personalized motivation system and peer support, lack of disciplined routine, improper time management that they experienced during the online mode of learning. Students realized and expressed the need of continuous physical interaction. Though these aspects are not directly related to so called 'content delivery' but they do have a great influence on the progress of effective learning. The students unanimously agreed that the school not only makes them self-sufficient with knowledge and skills, but it also provides them with the necessary learning environment and nurtures them mentally and emotionally. This, according to us, is one positive outcome that has emerged in these difficult times of the pandemic.

महामारीच्या काळात विज्ञान व गणित या विषयांची झालेली शैक्षणिक हानी
सौ. उषा गजानन वाघमारे व सौ. रिद्धी राजेश जाधव, न. मुं. मनपा शा. क्र.
6, करावे

' ही आवडते मज मनापासुनी शाळा,
लाविते लळा ही जशी माऊली बाळा'

ही कविता जेव्हा कानावर पडते तेव्हा कोरोना महामारी पूर्वीच्या शाळा डोळ्यासमोर उभ्या राहतात. सर्व जगातील मुले अगदी नित्यनियमाने शाळेत जात होती. शाळेतून मिळणारे अमृत रुपी बाळकडू ग्रहण करीत होती. शाळेच्या प्रांगणात हसत होती, खेळत होती, बागडत होती. त्यांना ज्ञान देणारा शिक्षक वर्गही आपल्या ज्ञानदानाच्या पवित्र कार्यात समान होता. अगदी बालवाडीपासून ते पदवी पर्यंतचे वर्ग सुरळीतपणे चालू होते. उद्योग जगतही आपला व्याप सांभाळून पुढची वाट चालत होता. नोकरदार वर्ग, महिलावर्ग सर्वजण आपापल्या कामात व्यस्त होते. अशा परिस्थितीत दि. 25 मार्च 2020 रोजी सर्वच ठप्प झाले. कोविड- 19 या जागतिक महामारी ने संपूर्ण जगाला विळखा घातला. सर्वकाही ठप्प झाले.

कोरोना महामारी मुळे जगातील सर्व क्षेत्रे प्रभावित झाली. दळणवळण, व्यापार, शिक्षण, पर्यटन ही सर्व क्षेत्रे ठप्प झाली. शिक्षण क्षेत्राला फार मोठा फटका बसला. बालवाडीपासून ते पदवीपर्यंत ची सर्व मुले घरी बसली. कोविडमुळे शाळा बंद पडल्याने ऑनलाइन शिक्षण हा नवा पर्याय समोर आला व ऑनलाइनच्या माध्यमातून 'शाळा बंद पण शिक्षण चालू' असे म्हणत शिक्षण देणे सुरू झाले.



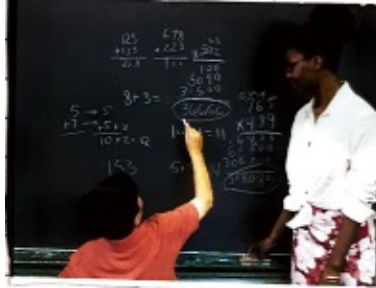
शिक्षणातील मूलभूत घटक म्हणजे 'अध्ययन- अध्यापन' प्रक्रिया होय. अध्यापन म्हणजे सराव आणि अनुभव यांच्याद्वारे वर्तनात घडून येणारे सापेक्षतः टिकाऊ स्वरूपाचे बदल तर अध्ययन म्हणजे नवीन प्रतिक्रियेचे संपादन आणि जुन्या प्रतिक्रियेचे विस्तारित संपादन होय.

शाळेत शिक्षकांना प्रत्यक्ष शिकवताना विद्यार्थ्यांचे अध्ययन होईल अशा प्रकारे निवेदन, चर्चा, मार्गदर्शन इत्यादी घटकांचा अवलंब करावा लागतो. अध्यापनातून विद्यार्थ्याला अधिक ज्ञान होणे, त्यांची आकलन शक्ती वाढणे, काही नवीन शक्ती सामर्थ्य लाभल्याचा आनंद होणे आणि त्याच्या प्रतिसादातून नव्या अध्यापनाला गती मिळणे

अपेक्षित आहे. विद्यार्थी शिकला याची साक्ष त्याच्या वर्तनातून दिसते. जे समजले नव्हते ते समजले व जे करता येत नव्हते ते करता येऊ लागले म्हणजे शिक्षण झाले असे आपण म्हणू शकतो.



शाळेत अध्यापक विविध विषय शिकवताना विविध प्रकारच्या अध्यापन पद्धतींचा अवलंब करीत असतो. उदाह-
रणार्थ, कथन, प्रश्नोत्तरे, चर्चा, प्रयोग, स्वाध्याय, प्रकल्प, निरीक्षण, अनुकरण इत्यादी. या सर्व पद्धतींचा अवलंब
करताना शिक्षक व विद्यार्थी यांच्यात प्रत्यक्ष आंतरक्रिया घडून येत असते. त्या आंतरक्रियेतून मिळालेल्या ज्ञा-
नाच्या मूल्यमापन कसोटीस विद्यार्थी उतरला म्हणजे त्याचे योग्य अध्यापन झाले असे म्हणता येईल. शाळेत
भाषा, इंग्रजी, गणित, समाजशास्त्र, विज्ञान असे विविध विषय शिकविले जातात हे विषय विविध अध्यापन पद्ध-
तींचा उपयोग करून शिकविले जातात. विज्ञानाचा विचार करता विज्ञान शिकविण्याचे उद्दिष्ट भौतिक घटनांतील
कार्यकारणभाव समजावा हे असल्यामुळे या विषयाच्या अध्यापनात विशिष्टाकडून सामान्याकडे जाणाऱ्या उद्दामी
पद्धतीचा अवलंब करावा लागतो. विज्ञानातील घटकाचे योग्य आकलन होण्यासाठी प्रत्यक्ष अनुभव घेऊन किंवा
कृती करून ज्ञान प्राप्त करण्याचा प्रयत्न करावा लागतो. यालाच आपण ' प्रायोगिक पद्धती' असेही म्हणतो.



An experiment is a study of cause and effect. म्हणूनच विज्ञानाच्या अध्यापनात कृतीद्वारे मुर्ताकडून
अमुर्ताकडे प्रत्यक्षाकडून अप्रत्यक्षाकडे या तंत्राचा प्रभावीपणे वापर करावा लागतो. गणित अध्यापनाकरिता दे-
खील प्रत्यक्ष प्रात्यक्षिकाद्वारे विविध साधनांचा वापर करून उद्दामी पद्धतीने शिक्षण द्यावे लागते. वहीवर किंवा
प्रत्यक्ष फळ्यावर गणिते सोडवून घेऊन कुठे चुका होत आहेत, ते पाहून नीटपणे समजावून द्यावे लागते.
भाषा, इंग्रजी, समाजशास्त्र यासारखे विषय व्याख्यान किंवा कथन पद्धतीने शिकविता येतात. परंतु विज्ञान व
गणित अध्यापनासाठी प्रत्यक्ष प्रात्यक्षिकाद्वारे समजावून सांगणे आवश्यक असते. कोरोना काळात संपूर्ण जगाचे
व्यवहार ठप्प झाले. शाळा बंद झाल्या. पण मुलांचे शिक्षण होणे तर महत्वाचे आहे. त्यातूनच ऑनलाईन शिक्ष-
णाचा पर्याय समोर आला. शाळेत जाऊन मुले शिक्षण घेतात तो आनंद वेगळाच असतो. तो आनंद ऑनलाईन
शिक्षण देऊ शकत नाही. कोरोनामुळे मात्र अशा ऑनलाईन पद्धतीत अपडेट राहणे गरजेचे झाले.



कोरोना महामारी ने जगाला बदलायला भाग पाडले. आपल्या शैक्षणिक संस्थांनीही हा बदल स्वीकारला. व्हाट्सअप, दीक्षा ॲप, युट्युब, झूम ॲप, गुगल मीट, विविध शैक्षणिक व्हिडिओज, सीडी, चॅनेल्स, शैक्षणिक वेबसाईट यांच्या माध्यमातून शिक्षण देण्यासाठी वातावरण तयार झाले. मुलांच्या शिक्षणासाठी पालकांनी मोबाईल, टॅब, लॅपटॉप खरेदी केले. या ऑनलाईन शिक्षण पद्धतीचे सर्वांना कुतुहल वाटू लागले. मुले शिक्षणात दंग झाली. परंतु नंतर समस्या येऊ लागल्या. पहिली आणि महत्वाची बाब म्हणजे आपल्या देशात बऱ्याच विद्यार्थ्यांची आर्थिक स्थिती चांगली नाही. त्यामुळे त्यांचे पालक महागडा मोबाईल किंवा लॅपटॉप घेऊ शकत नाहीत आणि म्हणून असे विद्यार्थी ऑनलाईन शिक्षणापासून वंचित राहिले. नेटवर्कची अडचण ही दुसरी बाब. तिसरी आणि सर्वात महत्वाची बाब म्हणजे सतत मोबाईल, संगणक यांच्यासमोर बसल्यामुळे मुलांना आरोग्याच्या अनेक समस्या उद्भवू लागल्या.



आता प्रत्यक्ष ऑनलाईन शिक्षणाबाबत. मागेच म्हटल्याप्रमाणे भाषा किंवा समाजशास्त्रासारखे विषय व्याख्यान पद्धतीने व्हिडिओच्या माध्यमातून प्रभावीपणे शिकविता येतात. पण गणित आणि विज्ञानाच्या अध्यापनाचे काय? जे विषय प्रत्यक्ष कृतीद्वारे, प्रात्यक्षिकाद्वारे, निरीक्षणातून शिकायचे आहेत, ते फक्त व्याख्यानातून कसे समजावून सांगणार? त्यातूनही आम्ही शिक्षकांनी जीवा व्हाईट बोर्डचा पर्याय स्वीकारला. त्यावर उदाहरणे सोडवून दाखविली. मुलांनाही सोडविण्यास सांगितली. परंतु प्रत्यक्ष वर्गात फळ्यावर, वहीवर उदाहरण सोडविताना मुलांना येणाऱ्या अडचणी लगेच दूर करता येतात. पण इथे ऑनलाईन तासाला प्रत्येक विद्यार्थ्याकडे वैयक्तिक लक्ष देऊन उदाहरणे सोडवून घेणे अशक्य झाले. त्यात विद्यार्थी प्रत्यक्ष काय करत आहेत हे शिक्षकांना दिसत नाही, त्यामुळे विद्यार्थी बेफिकीर झाले. शिक्षक प्रत्यक्ष समोर असताना ज्या प्रकारे विद्यार्थी लक्षपूर्वक आपले काम करतात, ती सोयच नसल्याने शिक्षकांनाही समजेना यांना खरंच घटक समजला आहे की नाही. त्यात असेही आढळले कि बरेच विद्यार्थी ऑनलाईन शिक्षणाला गांभीर्याने घेत नव्हते. विज्ञान आणि गणितासारखे प्रत्यक्ष प्रात्यक्षिकातून जाणून घेण्याचे विषय ऑनलाईन माध्यमातून यशस्वीरित्या शिकविणे कठीण झाले.



मुलांसमोर प्रत्यक्ष शिकविणे शिककाला चांगले वाटते. मुले समोर असतील तर त्यांच्या चेहऱ्यावरून अंदाज येतो, त्यांना समजले आहे की नाही, कंटाळा आलाय का? थांबायचे की पुन्हा सांगायचे का? वेगळ्या शब्दात किंवा वेगळी उदाहरणे देऊन सांगायचे का? कॅमेऱ्यासमोर शिकवायचे झाले तर वर्गाशी जो संवाद व्हायला हवा तो होत नाही. लेक्चर व्हिडिओच्या माध्यमातून पाठविले तरी मुले तो संपूर्ण बघतीलच असे नाही. लक्षपूर्वक ऐकतीलच असेही नाही. गणित शिकविताना त्यात विविध आकृत्या ठराविक मोजमापाच्या काढायच्या असतात. कॅमेऱ्यातून त्या अचूक आहेत की नाही याचा अंदाज कसा येणार? स्वाध्यायातील उदाहरणे मुले स्वतःला सोडवितात की युट्युब पाहून लिहितात हेही समजणे कठीण. विज्ञानाचा पाया प्रयोग आहे. कृती, निरीक्षण व त्या आधारे अनुमान काढणे प्रत्यक्ष अनुभवल्याशिवाय कसे शक्य होईल? ऑनलाइन शिक्षणात आम्ही शिक्षक व्हिडिओ द्वारे किंवा कॅमेऱ्यासमोर प्रयोग दाखवतो. पण विद्यार्थ्यांना प्रत्यक्ष अनुभवातून शिकण्याची संधी इथे मिळत नाही. घरी करण्यासाठी दिलेला प्रयोग मुले योग्यप्रकारे करतीलच याची शाश्वती नाही. ऑनलाईन शिक्षणाच्या माध्यमातून विद्यार्थ्यांचे प्रत्यक्ष मूल्यमापन करणे अवघड आहे. या सर्व समस्या पाहता असे लक्षात येते की ऑनलाईन पद्धतीच्या शिक्षणामुळे मुलांचा गणित व विज्ञान विषयाचा पाया डळमळीत झाला आहे.

समस्या अनेक आहेत. ज्या मुलांना आर्थिक स्थितीमुळे ऑनलाईन शिक्षण घेणे शक्य नाही, ती मुले या शिक्षण प्रवाहात मागे पडत आहेत. परंतु जी मुले ऑनलाईन शिक्षणात आहेत, त्यांच्या योग्य शिक्षणासाठी शक्य तितके प्रयत्न करणे क्रमप्राप्त आहे. गणित व विज्ञानाच्या प्रभावी अध्यापनासाठी ऑनलाईन प्रक्रियेतून ब्लॉग द्वारे, लाईव्ह चाट द्वारे, आर्टिकल, पोस्ट, व्हिडिओ च्या माध्यमातून जास्तीत जास्त चांगल्या प्रकारे शिक्षण देण्याचा प्रयत्न करणे हेच आता शिक्षकांच्या हातात आहे. शेवटी 'इच्छा तिथे मार्ग' हा असतोच. आधुनिक काळात असा आहे ऑनलाईन चा वापर वाढत आहे. मग ते क्षेत्र व्यापाराचे असो, खरेदी-विक्री असो, व्यवसाय असो युवा नोकरी चे असो, शिक्षण क्षेत्रही त्याला कसे अपवाद असेल?

कोरोनाच्या विळख्यातून संपूर्ण जग सुटेल तेव्हा सुटेल. पण ऑनलाईन प्रक्रियेद्वारे उपयुक्त माध्यमांचा वापर करून विद्यार्थ्यांचा व स्वतःचाही वेळ सत्कारणी लावणे हे सर्वस्वी शिक्षकांच्या हातात आहे आणि हाडाचा शिक्षक हे शिवधनुष्य पुरेपूर पेलून धरेल अशी शंभर टक्के खात्री आहे.

Effect of Covid – 19 Pandemic on Attendance of School–going Students and Challenges faced by them to Adapt to the virtual classroom– A Reconnaissance survey

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Introduction

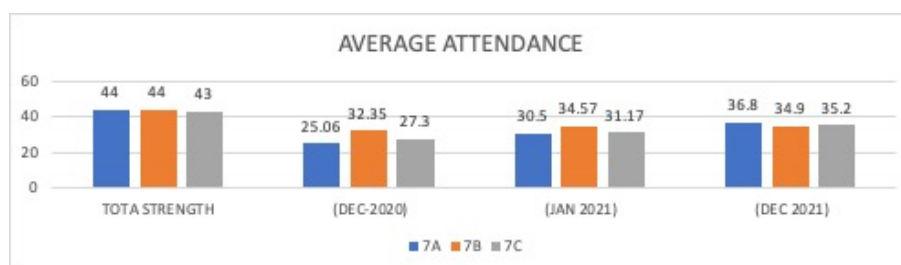
Berg and Colleagues (1997), defined School Refusal as a type of School attendance problem (SAPs) characterized by a young person's reluctance or refusal to attend school which leads to prolonged absences and remaining at home during school hours. School refusal and the number of absences could reduce academic achievement (Filippello et al.2019). A national survey conducted among U.S. parents of school-aged children found that school refusal was associated with parental fear of their child's susceptibility to COVID-19 infection. Absenteeism was prevalent before the COVID-19 pandemic. However, the pandemic has widened this gap. This has hit the learning level of the students. Studies predict that unfinished learning leads to low earning capacities. So, exploring the effect of the COVID-19 pandemic on the attendance of school-going children is of utmost importance.

Methodology

This study was conducted on 131 students of CBSE affiliated schools situated in New Panvel, Raigad district, Maharashtra. In this study, average attendance recorded in December and January of both the years 2020 and 2021 was computed. Secondly, absentees record was used to find out the reasons for the student being absent for online classes. A self-prepared questionnaire was used to find out the challenges in adapting to online virtual classes faced by the students of grades 6 to 10. The percentage of their responses was computed.

Analysis

Average Attendance during the months of December (2020) was 28.24,



for January (2021) was 32.08 and December 2021 was 35.6. The absentee's record showed the main cause for being absent was being unwell followed by shifting to a native place, network issues, and mobile unavailability. A questionnaire was prepared in Google forms and On analysis of the responses received from the students, it was found that 5.6% of students were shifted to their hometown during the onset of the pandemic. Fathers of 14.8% of students lost their job during COVID -19 pandemic which affected their online attendance. Concerning the advantages of on-line classes, 14.8% of students responded that they were able to stay at home, 11.1% found more time was available for them for self-study and 4.2% of the students responded that they could access many online study materials. However, 31.5% of the students selected too much screen time, 7.4% selected no peer interaction followed by 14.8% of the students found less interaction with the teacher, as some of the disadvantages of virtual classes. 51.9% of students found online classes somewhat enjoyable while 5.6% of students found it very unenjoyable.

From the responses received, it was also found that the majority of the students used laptops (46.5%), followed by smartphones (32.4%) and desktop computers (14.1%) as gadgets for attending online classes. A majority of mothers (74.6%) were found not working as compared to fathers (2.9%) who don't work. 2.8% of mothers and 12.7% of father's lost their job during the pandemic and 7.1% of the students responded that this loss of job affected their presence online. Most of the students reported that sickness, non-availability of phone, illness/emergencies in the family, and technical issues were the major reasons for being absent from online classes. Moreover, 53.5% of the respondents found virtual classes somewhat enjoyable, followed by 16.9% very enjoyable and 9.9% found online classes extremely

unenjoyable.

Conclusion

From the above data, we can conclude that all the factors like illness, shifting to hometowns, loss of parent's job, gadgets non-availability, network issues, etc hit the outcome and enthusiasm of the students learning process. All these factors are directly influencing the presence of students in virtual classes. Technology integration was a boon for the educators to provide non-stop learning opportunities for the learners. However, a few factors that acted as challenges, need to be considered while innovating better-uninterrupted platforms for learning and erasing equity and accessibility issues challenging innovators. According to Nathwani et al. (2021), there are currently no studies directly addressing the effect of COVID-19 and SAPs on academic performance, or child mental health and functioning. They also inferred that those children with SAPs seem to be more at risk of mental health issues, which may increase during the pandemic. Special attention by care providers and academic institutions should be provided to decrease the occurrence of SAPs and associated factors.

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Learning loss in Science and Mathematics during Pandemic

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The spread of SARS-COV-2 since March 2020 till date created troubles among the human population across the globe. It is very difficult to say, which stratum of the society is affected the least, since humans of all age groups suffered and are suffering more or less the same. Various surveys and studies suggest that the education sector is the worst affected due to covid pandemic. The damage happened to the students' community is irreparable. In Indian education system students learn languages, maths, science and social sciences which further continues in their graduate and post graduate studies depending on their choice. At school level, different topics learnt in maths like number, tables, basic operation through conventional chalk and board method always lasts forever. Further concepts of algebra, co-ordinate geometry, statistics, probability etc, are taught in higher secondary syllabus. These fundamentals are required in all competitive examinations conducted at national and international levels. Same is the case with science. Basic principles of Physics, chemistry and biology at secondary and higher secondary levels form the base of further studies. School is not only the place where teaching and learning takes place, but it is also an institution where every child learns meaning discipline, sharing, compassion, friendship, respect, hard work and obedience, which shapes one's life with morals and ethics.

At junior college level, students get acquainted with laboratories of physics, chemistry and biology and become confident to handle small equipment, glassware, microscopes etc. This exposure teaches them a lot. The concepts of vector algebra, trigonometry, integral calculus, matrices, sequences and series, become more clear in this age. The biggest advantage of in person learning is "direct interaction with the teacher" . Critical thinking, problem based teaching for science, solving maths exercises together, dis-

cussions and debates make students fundamentals very clear and strengthen the foundation. As we all are aware, in science and maths, merely teaching a topic is not enough, but students should i) understand the link between ongoing topic and previous topics ii) be able to correlate the principles of physics, chemistry and biology and learn independence. Moreover, different skills like comprehending the text, writing precise answers, drawing neat diagram, reading and recollecting, time management, logical thinking legible handwriting and many more develop when student are physically present in the class.

On the contrary, when science and maths are learnt in on-line mode, teacher does not know if the students are attentive. Many students do listen to recorded lectures but it is not a substitute to class-room reaching. It is evident from study, reported by Chemath (a company offering after school classes in maths and coding). 1200 samples across 6 metros like Delhi Mumbai, Bengaluru, Kolkatta, Chennai and Hyderabad for classes 1 to 12 were included in this study to understand parents' perceptions and concerns in their child's learning. 25% parents of students up to grade 5 believe learning loss is severe in maths in past 18 months. i.e. forgetting basic concepts and inability to grasp fundamentals. 20% parents of higher grade students feel geometry and mensuration are difficult topics to comprehend 44% parents have reported fear for maths. Many ed-tech start-ups have their teaching programs for all grades. If this is the solution to the problems created by pandemic then schools will eventually become redundant. But that is not the case as seen from results of school / college and university examinations. Ironically average and below average students have scored more than 90% marks in on-line examinations which indicates flaws in the system. Remote learning is more challenging due to less time spent in learning, increased stress, fewer interactions with peers and teachers and reduced learning motivation.

This has led to other problems in sincere students like increased competition, anxiety, depression, loneliness and lack of interest in studies. Various surveys in western countries also suggest that students on an average are

5—6 months behind in maths and 4—5 months behind in reading. And those who moved to next grade are unprepared and miss key building blocks of knowledge.

Coming to graduate and postgraduate programs, although students are mature enough to undertake self studies, maths and science demand classroom teaching and hand-on training. Virtual learning does not equip the students to work independently in the laboratories. They lack planning and interpretation skills that is needed in industry, research, teaching and in start-ups. These students miserably fail in off-line exams of theory and practical courses. Having spent two years in the pandemic with on-line evaluation, there is a permanent fear for offline exams among the students. The crisis had also an impact on mental health and well being of students. Students of final year are at risk of finishing education without skills behaviour and mindsets to succeed in the workforce. Thus, the cumulative effects of pandemic on college students could have long term impact like lower earnings, lower levels of education attainment, less innovation leading to decreased economic productivity. Of course, every cloud has a silver line. Technology helped all of us during pandemic. All college and school teachers underwent training to use online platforms like google, TEAMS etc. Audio-visual aids, practical videos, demonstrations and recorded lectures benefited the students. College students actively participated in webinars and on-line workshops. However school trips excursions, industry visits, educational tours, various competitions at local/state/national level and many more events which help to nurture the students could not happen. And this is a major loss.

In conclusion, the extent and nature of loss is serious enough to warrant action at all levels. Policy and processes to identify this loss are necessary as children return to schools. Key findings of a survey in India across classes 2-6d, in 44 districts involving 1137 public schools including 16067 children, suggest 82% of children have lost at least one specific mathematical ability from the previous years across the classes.

These findings indicate that additional support in form of bridge coursed,

extended hours, community based engagements and appropriate curricular materials will be needed to help children gain the foundational abilities. Also the teachers must be given enough time to compensate for both kinds of learning loss and we must not rush into promoting children to the next class.

Considering the current spread omicron variant consistent fear of lockdown and other restrictions certain improvements in on-line teaching may prove helpful. For example 1) schools / colleges partnering with psychologists to help students with maths activities ii) incorporation of short anti-stress exercises while remote learning, iii) use of various apps and worksheets to practice the procedure, iv) use of algorithms in computer based playlist to map and deliver customised lessons. V) Use of short videos or chats for parents vi) use of maths related games etc. Thus focused efforts of students, teachers and parents would definitely help students to regain their maths and science competencies, in both scenarios i.e. if schools / colleges reopen and continue with offline programs or on-line teaching - learning continues with prevailing pandemic. We hope for the best and wish good luck to all students.

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विज्ञान विषयाचे ऑनलाइन अध्ययन-अध्यापन करताना येणाऱ्या समस्या व फायदे

सारिका विठ्ठल खातेल, न. मुं. मनपा शा. क्र. 22.

उगा दुरुनी पाणी टाकुनी
कसा फुलेल हो मळा
काय सांगू मी, कशी वाटते
ऑनलाइन भरली शाळा

समोर शिकणाऱ्या मुलांची शाळा आता बंद झाली, चार भिंतीतली शाळा आता मोबाईलच्या स्क्रीन वर येऊन थांबली. इथे पर्यंतचा प्रवास या निबंधा च्या माध्यमातून मी मांडत आहे. 2020 मध्ये आलेल्या कोरोना महामारी मुळे संपूर्ण जगभरात ऑनलाइन शिक्षण प्रसारित झाले आहे. आज प्रत्येक विद्यार्थी मोबाईल आणि संगणकावर शिकू लागला आहे. ऑनलाइन शिक्षणाला आजच्या आधुनिक जगाचा एक भाग म्हटले तरी चालेल. सुरुवातीला शाळा बंद झाल्या, तेव्हा नंतर अनेकांच्या मनात हा प्रश्न नक्कीच घर करून गेला असणार की आता हा कोरोना केव्हा संपेल आणि मुलांच्या शिक्षणाचे काय होईल? नंतर जेव्हा ऑनलाईन शिक्षणाचा तोडगा काढला गेला तेव्हा केव्हा, कसे सर्व जमेल, तसे होईल असे असंख्य प्रश्नांनी शिक्षकांच्या पोटात गोळा उठला होता.

पण म्हणतात ना, " बुडत्याला काडीचा आधार" या उक्तीप्रमाणे ऑनलाइन प्रणालीमुळे संगणक, इंटरनेट सुविधेमुळे आपला जीव नक्कीच भांड्यात पडला असेल. विज्ञानामुळे आजच्या जगाचा प्रवास अधिक सुखी, समाधानी व अधिक सोयीस्कर बनला आहे. म्हणून मला खालील गीत आठवते...

विज्ञानाचे युग हे आले,
चला स्वागता सामोरे,
झटकून टाका जुन्या निराशा,
मिळतील नवीन आशा.

देशभरात पसरलेला कोरोना आणि त्यामुळे आलेल्या संकटामुळे विद्यार्थ्यांना व शिक्षकांना घराच्या बाहेर न पडता घरबसल्या शिक्षणाचा लाभ घेता येत आहे. विज्ञान विषयाचे अध्ययन-अध्यापन करताना विद्यार्थी व शिक्षक यांच्या प्रवासाची व वेळेची बचत झाली आहे. तसेच ऑनलाइन शिक्षणामुळे शिक्षक व विद्यार्थी यांना लॅपटॉप, मोबाईल, संगणक यांचा वापर चांगल्या प्रकारे करता येऊ लागला आहे.

ऑनलाइन विज्ञान शिक्षणाने विद्यार्थ्यांना पुन्हा-पुन्हा न समजलेल्या घटकाचे व्हिडिओ पाहता येतात. त्यांचा सराव करता येतो. तसेच वेगवेगळ्या विज्ञान शिक्षकांचे मार्गदर्शन मिळते. तसेच ऑनलाइन शिक्षणामुळे शिक्षक व विद्यार्थी जास्तीत जास्त वेळ एकमेकांच्या संपर्कात राहू शकतात. तसेच शिक्षक-विद्यार्थी आपल्या सोयीनुसार

विज्ञान विषयाचे अध्यापन-अध्ययन करू शकतात. तसेच ऑनलाइन शिक्षणामुळे एकाच गोष्टीचे अनेक पैलू विद्यार्थ्यांना पहायला मिळतात. त्यामुळे त्यांच्या ज्ञानकक्षा रुंदावतात.

तसेच ऑनलाइन शिक्षण गरीब-श्रीमंत असा भेदभाव न करता ते सर्वांना उत्कृष्ट दर्जेदार समान शिक्षण देते आणि तेही समान मूल्यामध्ये.

कोरोना न डाल पाए शिक्षा पर कोई प्रभाव
यही है ऑनलाइन शिक्षा का मुख्य आधार।"

वर्तमान काळात कोरोना काळात ऑनलाईन शिक्षण अत्यंत आवश्यक आहे. सुलभदायी असल्यामुळे थोड्याच काळात ऑनलाइन शिक्षण अत्यंत प्रभावी ठरले. लॉक डाऊन च्या कठीण काळात जेव्हा सर्व शाळा आणि कॉलेज बंद होते तेव्हा ऑनलाईन शिक्षणानेच विद्यार्थी व शिक्षक यांच्या सर्व समस्यांचे समाधान केले आहे. हे म्हणणे चुकीचे ठरणार नाही की या कठीण प्रसंगांमध्ये विद्यार्थ्यांचे शिक्षण ऑनलाइन शिवाय होणे असंभवच आहे. ऑनलाइन विज्ञान अभ्यासामुळे मुलांमध्ये घरातच उपलब्ध असलेल्या गोष्टीतून काहीतरी नवीन करण्याचा छंद निर्माण झाला आहे. तसेच ऑनलाईन शिक्षणामुळे पैशांचीही बचत होते. वेगवेगळे कोर्स मोजक्या शुल्कात आपल्याला उपलब्ध होतात. तसेच एलेक्सा सारख्या नवनवीन ॲपच्या माध्यमातून आपण टाईप न करता साऊंड सिस्टिम द्वारे आपल्याला हवी ती माहिती सहज उपलब्ध होते. आणि तेही कधीही, कुठेही आणि वेगवेगळ्या भाषेत...

ऑनलाइन शिक्षणामुळे जग जवळ आल्यासारखे वाटत आहे. ऑनलाइन शिक्षणामुळे कॉम्पिटिशन मध्ये भाग घेण्याची, ते पचवण्याची, अजून नव्याने पुन्हा उभे राहण्याची ताकद निर्माण होण्यास मदत मिळाली आहे. आपले जग, आपली स्पर्धा ही आपल्या पुरतीच मर्यादित न राहता त्याची ही व्याप्ती वाढली आहे. त्यामुळे विद्यार्थ्यांना, शिक्षकांना वेगवेगळ्या आव्हानांना सामोरे जाण्याची सकारात्मक ऊर्जा निर्माण झाली आहे.

विज्ञान हा विषय ऑनलाइन शिकताना वेगवेगळ्या शास्त्रज्ञांची माहिती तसेच त्यांनी केलेल्या एक्सपेरिमेंट्स अधिक माहिती मिळते. तसेच व्याख्यानाचा वेग जास्त असल्यामुळे बऱ्याच विद्यार्थ्यांना नोट्स घेण्यास त्रास होतो म्हणून त्यांच्या नोट्स मध्ये बऱ्याचदा महत्वाचे मुद्दे गमावले जातात. व्हिडिओ स्टॉप करून रिव्हाइंड करून पुन्हा पाहू शकतात.

ऑनलाइन शिक्षण प्रणालीच्या मदतीने अगदी लहान शहरे आणि दुर्गम भागातील विद्यार्थीही उच्च गुणवत्तेचे ऑन-लाइन शिक्षण घेऊ शकतात. अशा दर्जेदार शिक्षण घेण्याची किंमत ही खूप कमी आहे. यामुळे छोट्या शहरांमधील विद्यार्थ्यांना इतर विद्यार्थ्यांसह स्पर्धा करण्याची समान संधी मिळते.

प्रत्येक नाण्याच्या दोन बाजू असतात. तशाच ऑनलाइन विज्ञान विषय अध्ययन-अध्यापन करताना येणाऱ्या काही समस्याही आहेत.

मोबाईल लॅपटॉपच्या स्क्रीन समोर, भरली आमची शाळा.

दप्तर नाही, ओझे नाही, पाठ दुखणे थांबले,

डोळे मात्र बारीक झाले, डोळे दुखणं वाढलं,
पायपीट नाही, ट्रॉफिक नाही, शाळा चं घरात आलीय,
जाता-येताना रस्त्यावरची ती दंगामस्ती हरवून गेलीय

लांब ऑनलाइन वर्ग मुळे डोळ्यात वेदना आणि सूज उद्भवू शकते. जे सतत पाच-सहा तास स्क्रीन पाहण्यामुळे होते. डोळे कोरडे होतात. चिडचिड होते. पाठ दुखी सारख्या आरोग्य समस्या उद्भवू लागल्या आहेत. तसेच बरेच विद्यार्थ्यांना चष्मे लागण्याचे प्रमाणही वाढले आहे.

ऑनलाइन वर्गात प्रश्न विचारू शकत नाही. ऑनलाइन वर्गात विद्यार्थ्यांना जेव्हा काही शंका असेल तेव्हा हात वर करू शकत नाहीत किंवा एखादा घटक विद्यार्थ्याला समजेलच अशी खात्री विद्यार्थी व शिक्षकांना मिळेलच असे नाही.

इंटरनेट कनेक्टिव्हिटी आणि स्पीड मुळे सगळ्यांनाच त्याचा लाभ त्या त्या प्रमाणात होत नाही आणि प्रत्येकाकडे स्मार्टफोन असेलच असे नाही आणि असला तरी एका घरात फोन मात्र एक आणि दोन तीन भावंडे त्यामुळे त्यांच्या शिक्षणाला समस्या येतात. तसेच आमच्याकडे शिकणारी मुले ही झोपडपट्टीतील असल्यामुळे त्यांचे आई-वडील हे मोलमजुरी करण्यासाठी दिवसभर बाहेरच असतात त्यामुळे त्यांना फोन मिळतच नाही.

तसेच विज्ञान विषय ऑनलाइन शिकवताना विज्ञान संकल्पना स्पष्ट करताना अडचणी येतात. विज्ञान हा प्रयोगातून शिकण्याचा विषय असल्याने निरीक्षण, कृती, निष्कर्ष या महत्वाच्या बाबी ऑनलाइन शिक्षणाने प्रत्येक विद्यार्थ्यांपर्यंत पोहोचणे शक्य नसते.

विज्ञानाच्या संकल्पना वैज्ञानिक भाषेत असल्याने त्या समजून सांगताना विद्यार्थ्यांच्या आकलन क्षमतेचा विचार करावा लागतो. मात्र ऑनलाईन पद्धतीने ते शक्य होत नाही.

प्रत्येक विद्यार्थी इतरांपेक्षा भिन्न असतो. परिणामी त्याच्या अध्ययन आणि आकलन क्षमता ही भिन्न असतात. परिणामी प्रत्येक विद्यार्थ्यांच्या क्षमता समजावून घेऊन अध्यापन करणे शक्य होत नाही. तसेच ऑनलाइन अध्ययन करताना विद्यार्थी अभ्यासापेक्षा इतर बाबींसाठी मोबाइलचा वापर करताना दिसत आहे. वेगवेगळे व्हिडिओ पाहणे, त्या माध्यमातून तो सकारात्मक बाबींचा विचार करेल हे सांगणे तितकेच कठीण आहे आणि त्याच्या विद्यार्थी मनावर वाईट परिणाम होत आहे. ही बाब गांभीर्यजनक आहे.

तसेच ऑनलाइन शिक्षणामुळे विद्यार्थी आळशी होत चालला आहे. तसेच ऑनलाईन शिक्षणामुळे एकत्रित शिकण्याचा, एकमेकांच्या अनुभवाचा, सामाजिक भावनांचा न्हास झाला आहे.

परंतु कोरोना कालावधीत ऑनलाईन शिक्षणाला मर्यादा किंवा समस्या जरी असल्या तरी ऑनलाईन शिक्षणामुळे शिक्षण ही निरंतर प्रक्रिया सुरळीत चालण्यासाठी मदत झाली आहे हेही तितकेच खरे आहे. ऑनलाईन शिक्षणामुळे शिक्षक-विद्यार्थी आदान-प्रदान न थांबता नियमित चालू राहिले आहे.

ऑनलाईन शिक्षणामध्ये विज्ञान विषय शिकवण्यात येणा-या अडचणी व त्यावर केलेली मात

श्री. भास्कर जानू भोये, नवी मुंबई महानगरपालिका शाळा क्र. 34, श्रमिकनगर

कोरोनाच्या वाढत्या प्रादुर्भावामुळे लॉकडाऊन सुरू झाले. ज्ञानमंदिरे ओस पडली. ज्ञान मंदिरात दिले जाणारे शिक्षण जागतिक संकटामुळे बंधनात अडकले. शाळा उघडणारच नसल्यामुळे आता घरातच बसून ऑनलाईन शिक्षण घ्यावे लागणार. ऑनलाईन शिक्षण आपल्याला खूपच नवीन होते. त्यामुळे माहितीही फार कमी होती. घरच्या घरी शाळा हा पर्याय होऊ शकतो का? विद्यार्थी शिक्षणापासून वंचित तर राहणार नाही ना? ऑनलाईन शिक्षण घेतांना अशा एका मागून एक अडचणी समोर येऊ लागल्या. शिक्षण घेण्यासाठी मोबाईल, टॅब, लॅपटॉप या साधनांची गरज लागणार होती. ती सर्वांकडे उपलब्ध नव्हती. रोजगार बंद झाल्यामुळे आर्थिक समस्या निर्माण झाली. रिचार्जसाठी पैसे नव्हते. अनेक विद्यार्थी संपर्काच्या बाहेर झाले. ऑनलाईन शिक्षणाची पालकांची मानसिकता नव्हती. मुलांकडे मोबाईल देण्याची पालकांची तयारी नव्हती. मुलांना या शिक्षणाची सवय नव्हती. या सर्व अडचणींचा विचार करता त्यावर मार्ग शोधायला सुरुवात केली. व्हॉटसअॅपच्या माध्यमातून ग्रुप तयार करून विद्यार्थ्यांशी संपर्क वाढवण्याचा प्रयत्न केला. विविध अॅपच्या साहाय्याने ऑनलाईन अध्यापन सुरू केले. सर्वच विषयांचे ऑनलाईन शिक्षण देणे कितपत शक्य होईल? अशी शंका मनात आली. प्रश्न होता तो विज्ञानासारख्या प्रात्यक्षिकांतून शिकवणा-या विषयाचा. त्यासाठी सहज उपलब्ध असलेल्या साधनसा-मग्रीतून विविध प्रयोग-प्रतिकृती बनवून त्याची प्रात्यक्षिके दाखवली. अॅमेझॉन स्टिम लॅबच्या सहकार्यातून छोट्या-छोट्या प्रात्यक्षिकांसाठी कुरीयरमार्फत साहित्य पुरवले. त्यांच्यामुळे विज्ञानाची ऑनलाईन प्रात्यक्षिके व्यवस्थितपणे पार पडली. विद्यार्थ्यांत विज्ञान विषयाची आवड निर्माण झाली. शिक्षणासाठी मोबाईल नव्हते अशा मुलांना स्टिम लॅबमार्फत 25 टॅब पुरविण्यात आले आणि त्यांना शिक्षण प्रवाहात आणण्याची मोठी समस्या सुटली. सरावासाठी प्रात्यक्षिकांच्या वर्कशीट वाटप केल्या. नवी मुंबई शिक्षण विभागाने विद्यार्थ्यांच्या मोबाईल रिचार्जसाठी प्रत्येकी एक हजार रुपये दिले आणि आणखी एक समस्या सुटली. ऑनलाईन शिक्षणातील एक-एक समस्या दूर होऊ लागली. पालकांच्या भेटी घेऊन मुलांना ऑनलाईन शिक्षण किती गरजेचे आणि महत्त्वाचे आहे हे पटवून सांगितले. त्याचाही फायदा झाला. हळूहळू ऑनलाईन शिक्षणाला विद्यार्थ्यांची हजेरी वाढली. शाळेत जाऊन मुले जे शिक्षण घेतात, तो आनंद वेगळाच असतो. तो आनंद ऑनलाईन शिक्षण देऊ शकत नाही. याची खूप तीव्रतेने जाणिव झाली; पण त्याशिवाय आपल्याकडे पर्याय नव्हता. या जागतिक संकटामुळे ऑनलाईन शिक्षणात शिक्षक, विद्यार्थी व पालक यांना अपडेट राहणे गरजेचे झाले. त्यामुळे वरील समस्यांवर उपाय शोधण्यास सुरुवात केली तशी मीही केली. केलेल्या प्रयत्नांना थोड्याफार प्रमाणात यश मिळाले. ऑनलाईन शिक्षणामुळे विद्यार्थ्यांना शिक्षकांकडून मिळणारा आनंद कमी होऊ लागला आहे. त्यातूनही शिक्षक अनेक मार्ग काढतील; कारण बदल होतच राहतात यावर विश्वास ठेवला पाहिजे. असेही होऊ शकते की मुले स्व-अभ्यासात स्वतःला गुंतवू पाहतील, नवीन छंद जोपासतील, नवनवीन गोष्टी शिकण्याकडे कल वाढेल.

Teachers as facilitators in different learning environment

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A facilitator is a person who helps a group of people to work together better, understand their common objectives, and plan how to achieve these objectives.

Teachers are the ones with knowledge and expertise in a particular field. They impart that knowledge through a variety of means to their students. Facilitators build on the knowledge base of the group of students to find the answers to questions. Both methods of instruction serve a purpose and allow students the chance to grow.

By asking questions and keeping the group focused, a facilitator helps the group establish a set of ground rules, as well as its own learning objectives. The facilitator also helps the group evaluate what group members learned from their activities.

Often, crossover occurs with teachers as facilitator and facilitators as teachers. In order for either to be successful, she must be an active listener. Facilitators in particular make use of this skill. They listen to an entire statement made by a group member before responding. They try to understand the group member's point of view in a nonjudgmental way.

Facilitation offers everyone in the group the chance to express their ideas and to feel as if they are part of a team. Since the group arrives at a mutual conclusion, it's easier for individual members to carry out the group's goals and to feel less inclined to work on individual agendas. The role of facilitator in school is to help individuals build on their skills and learn new ones. Facilitation serves as a positive way to resolve conflicts and clarify misunderstandings among a diverse group of individuals.

There are different methods to promote learning. Some are student-centered-like library work, project work, experimentation home assignment etc. where major focus is on how student organize their steps of learning by interact-

ing within different environmental components like printed matter, natural realities etc. All such methods show that teacher guides students as to how to go about learning sequence, this facilitating their learning.

The teacher should be knowledgeable, enthusiastic, approachable and caring. The teacher should give constructive feedback and supports less able students, using a wide variety of teaching methods. The teacher should be responsible risk taker and willing to innovate. The teacher should appreciate the creativity of the students and encourage their thinking 'outside the box'. The teacher should encourage the questioning attitude of the students. The focus in the classroom is on how to learn rather than what to learn.

Teachers must adapt to a new way of teaching by managing more open ended discovery by students. This means shifting roles from a lecturer to a facilitator who provides resources, monitors progress and encourages students to problem solve. Teachers reap benefits when they see how excited their students are about applying their knowledge to solve a problem. Facilitative learning requires that students do the work. However, many students, especially those who prefer to know "how to get an A," are uncomfortable with the open-ended design of facilitative learning. They are not familiar with projects that require them to apply their knowledge and problem solve. So, at first, students can get frustrated. Teachers must teach students to manage their own learning. The result will be students who are more creative and able to apply their learning to life's challenges. An added benefit is that teachers find once the shift to facilitative learning is implemented, students are more motivated in the classroom resulting in fewer discipline problems.

Facilitative learning requires students to apply their knowledge across subjects and that requires teachers in different disciplines to work together. Teachers feel comfortable managing their own classrooms but sometimes may not be used to working with their peers. Teachers must use facilitation skills to find positive ways of working on a single project with teachers in other disciplines. As a result, teachers find that working with their peers

offers them more resources and ideas to share with students in their classrooms.

When we are acting like a facilitator we face a problem due to number of students but that problem can be solved by distributing students in several groups so that students can perform that activity in their allotted group. They will try to understand the concept behind that activity. To act as a facilitator instead of authoritarian really helps in teaching faster, effectively and productivity because when we act like an authoritarian we need to explain a concept several times to get it understood by the students but when we act like a facilitator students perform activity by their own. They observe, analyze and conclude by themselves so it is easier for them to understand the concepts and the understood concepts would be long lasting in their memories.

Facilitation offers everyone in the group the chance to express their ideas and to feel as if they are part of a team. Since the group arrives at a mutual conclusion, it's easier for individual members to carry out the group's goals and to feel less inclined to work on individual agendas. The role of a facilitator in school is to help individuals build on their skills and learn new ones. Facilitation serves as a positive way to resolve conflicts and clarify misunderstandings among a diverse group of individuals.

For example, if a teacher needs to explain the correlation between work and energy, each student in a group will be expected to take a possible number of rounds around the school by running and how many rounds each person takes will show the capacity of that person to do a work and that is nothing but the energy and this conclusion will be done by each one of them in a group.

Adding holistic contributions during an unconventional journey
of language editing

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Introduction and Vigyan Pratibha background

To reach a wider community of students and teachers and make learning more accessible, we (the Vigyan Pratibha team) decided to translate the Vigyan Pratibha Learning Units into some regional languages, including Marathi. The Learning Units (LU's) are educational resources core to the Vigyan Pratibha programme and were developed in English in the pilot phase of the project. These learning units are conducted by school teachers with interested students and are aimed to enrich students' science and mathematics learning experiences. The units aim at motivating students to engage in various tools of science and mathematics like asking questions, designing experiments, making and noting observations or taking interviews. We believe that the availability of such learning resources in regional languages would not only widen the scope of the project but will also stimulate better discussions, interactions and expressions.

Translations might appear to be simple post-processing tasks, but in reality, finalising a translated document, especially a scientific document/educational resource can be a much more complex process. During translation, one should always keep in mind the different characteristics of languages involved and how each of the languages interplays with scientific terms and vocabulary. Apart from these, finalising the translations of the LUs also allowed us to relook at the original LUs and work towards making them more accessible and consistent.

The team had several discussions about these aspects during decision-making in the translation process. Some interesting anecdotes about sensitization to choice of words, prescribed gender roles, etc were observed. Many

times, teachers also have to do some translation, either oral or verbal. This paper aims to create awareness and sensitivity in the science community concerning the translations. The specific examples presented here are about "English to Marathi" translation scenarios but the issues might apply to other language translations too.

Gender sensitization

The primary task of the editing team was to read the already translated LU and decide whether the translation was doing justice to the original document concerning its philosophy towards science education, tone of sentences (not too formal/authoritative for students), and the science content. But this task quickly changed to a more genuine responsibility where the team had to decide how issues like lack of appropriate words in the translated language can be dealt with. For example, the most common translation for the word 'friend' in Marathi is "मित्र". The word 'friend' is supposedly inclusive in English, but in Marathi, it typically refers to male friends. After a lot of discussions, the team decided that the word 'इतर' which means others, including everybody in the class was a better option, though not a strict translation.

A similar gender role situation arose in the translation of the learning unit 'Moon and its shape'. The LU involves a role-playing activity with the Sun, the Moon, and the Earth as three characters to be played by students. In the original document, gender-neutral term 'student' was used to describe this role-play activity, but in the original Marathi translation the Marathi word, 'विद्यार्थी' was used for all students, this might be because of lack of gender-neutral words for 'student' in Marathi. The interpretation of this can be that only male students should participate in the role-playing activity. Hence distributing the roles among girls and boys was imperative. While distributing the roles among girls and boys, it can happen that the roles of the Sun and the Moon would be assigned to male students (विद्यार्थी) while the role of the Earth would be assigned to a female student (विद्यार्थिनी), as traditionally the Sun and Moon are always described as males (सूर्यदेव, चांदोमा/ चांदोबा) while the Earth is always addressed as a female (धरती माता, धरणी)

entity. In the final version, it was decided that female students would be shown to play the roles of the Sun and the Moon and a male student will be shown playing the role of the Earth. These conventions need to be reviewed and corrected especially in the case of content meant for young adults and children.

The adjustment in a written document might look trivial but can help remove gender stereotypes and reduce the possibilities of only a certain group of genders taking active participation if translations are done literally.

Identifying precise and meaningful words

Another important factor we noticed while editing the translated documents was the lack of Marathi words for concepts that are precisely defined in higher mathematics and science but make an early appearance at the school level. The majority of the higher science and mathematics books found in India are in English and the available Marathi books, which are rare, use Sanskritised versions of such words. Concepts like conjectures and verification are used in different ways in our classrooms. Like when a teacher writes a pattern and asks her students to make a 'conjecture' about the pattern. The team together worked out words from the Marathi language which would fit more appropriately in the contexts like using 'अनुमान लावणे' for making conjectures instead of 'अंदाज करणे'.

Socio-cultural sensitivity

Apart from working on the translated document, this editing process also made it possible for us to review the original documents with an added socio-cultural sensitivity. For instance, the LU 'Twists in fibres', which as its name suggests deals with the intricacies of fibres, has a section on the burning test of fibres. In the context of burning an animal-based fibre, the original document initially described the odour as 'unpleasant odour'. This odour is similar to the smell produced when other animal-based proteins such as meat are burned. Sensory categorisations are personal and what people find pleasant or not can't necessarily be defined in scientific or generalised terms. Moreover, we felt that calling this odour unpleasant may detach people who like the odour or people whose occupations involve burn-

ing animal-based proteins from the discussions. The process of editing the translation gave us a lens and the time to look into issues like the ones mentioned above with added socio-cultural sensitivity and address some of these together with the authors.

Final comment

This article is written to pinpoint issues one might encounter while translating documents or editing translations and to reflect on how the entire process can provide insights for holistic contributions to educational resources at all stages.

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Reference

<https://vigyanpratibha.in/>

Connecting Science and Society

Ms. Sheema Khan, Podar International School, CBSE, Nerul

Introduction

The pre - and post - Covid world has witnessed and precipitated dramatic transformations across all the sectors, more so in the educational realm. This has given rise to multifarious situations that have seen a compelling connection being forged between science and society, wherein upgradation and flux have been the order of the day.

Body

Since times immemorial, when humans developed rudimentary complements of science to the current times, where scientific pursuit has led to an impressive array of discoveries, inventions and innovations, society and science have always been intertwined.

The synergy has been more pronounced in the recent years which has witnessed the dawn of an era of information explosion wherein data, content, information and knowledge has been created at a hitherto unknown quantum and quality. Nothing can be more pertinent to prove this than the fact that more data has been produced in the last two years than has been created in two millennia of human civilization gone by!

It goes without saying that science, in its myriad manifestations, has impacted, every epoch of human existence till date and shall continue to do so, probably, in a more pronounced manner, in the future too. There is no segment of human existence and societal functioning which has not been impacted by its utilities. Governments, businesses, institutions, vocations, services, you name it, every entity on the face of this world, is facilitated in its functioning by multiple applications of scientific achievements and technological expositions and the educational sector is no exception to this rule. With the onset of the Covid-19 epidemic which rapidly metamorphosed into a global pandemic; life, living, and livelihoods, in fact the very existence of humanity, is at the whims and fancies of an evolutionary enigma, dubbed

as the Corona Virus. However, human intellect, resilience and survival instinct is making it more reassuring every day that we, humans, shall soon exhaustively decode and comprehensively decimate this rapidly mutating threat to our way of life.

Nevertheless, while all these life-changing experiences have been happening, a huge quorum of limitations and restrictions have had to be and are still being contended with by the educational sector. Schools and other institutions of learning have been closed for indefinite periods of time and the faculties and students alike have had to adapt to a new online mode and in some cases, a hybrid mode of teaching and learning. A phenomenon which has thrown up its own share of challenges to be dealt with.

Now to overcome these challenges, some of which had the potential to be debilitating, science and technological innovations came to the rescue of all the stakeholders, be they institutions, management, faculties, students and parents. Though it goes without saying that socio-economic inequities, lack of technological access and acquaintance, curriculum architecture, policy deficits, pedagogical methodologies, SOP compliance et.al did create and still continue to put spanners in the process.

Science, as a subject, is unique, in the sense that it is empirical in nature and is based on, observation or experience rather than theory or pure logic. So even for something as basic as concept clarity, I invite a lot of queries from students as this provides an interactive engagement platform which in a virtual classroom is facilitated by various technological tools.

Other than following the standard curricular formats in virtual classrooms, one of the main items discussed on a regular basis has been the pandemic; its ramifications and repercussions, anxieties and apprehensions, impact and implications. Being a science teacher, it has been my prerogative to integrate the outside world with the virtual class by plugging in real-life scenarios, circumstances and experiences while explaining a host of scientific principles, precepts and topics.

Besides doling out information to students on various topics or assigning project work, real-life circumstances prevalent in their homes, neighbor-

hood or communities are brought to the fore to serve as inspirations to the students, firing up their imagination, motivating them in their endeavors and helping them accomplish their tasks. All this happens in a “real-time” continuum only because advanced technologies are there to ensure streamlined interactions, observations and inferences.

Other than that, while discussing various topics via online platforms, a diverse quorum of opinions, expressions, queries, answers crop up in every class which create newer, better possibilities of explaining and understanding the subject. The analysis of this disparate quorum of responses provides interesting insights which further facilitate improvement, both in pedagogy as well as learning by the students.

Technology is a great enabler and virtual classrooms are one of the best examples that cement this claim. Online meeting platforms like MS Teams, Zoom, Google Meet, et.al, the conduct of quizzes and exams PowerPoint presentations, showcasing YouTube videos, graphic storytelling, interactive debates are some of the examples of technological interventions that have helped sustain and enhance student learning as well as ramp up the tool kit of teachers making virtual classrooms an enlightening and immersive experience.

During this pandemic, huge transitions and transformations have been affected between teachers and students, teachers and parents and lastly parents and students on all fronts. One common thread that runs through all the above listed relationships has been the increase in the tech-savvy quotient, which initially posed some hurdles but later got finetuned by gradual acquaintance and acceptance.

Furthermore, student absenteeism, personal/familial trauma, parental economic crises, is a potential combination that can effectively curtail student motivation and participation, however technology offered plausible anonymity, remote access and round the clock facilitation that ensured that students do not miss out on critical and urgent understanding briefs. Teachers are able to effectively intervene to showcase empathy and deliver facilitation to help students overcome fear, loss and many other demotivating

variables.

Conclusion

This pandemic, besides all the havoc that it has wreaked on humanity, has amongst other things witnessed a near perfect synergy between society and science. We are a highly networked mesh of entities, witnessing an almost daily increment in human scientific prowess and its applications, specifically in the educational space. This space is at the forefront of technology adoption as well as adaptation. I often find myself amazed at the utilities, teaching aids et.al that are introduced at a regular pace to make teaching and learning, a student-centric activity.

This is a society that has crafted a perennial and commendable relationship with science which in turn has seen teachers across the board exceed their brief, ace their limitations, spruce up their competencies to deliver effective learning, mould the personalities, and ensure a perpetual quest for excellence in students, who are trying to come to terms with what are essentially trying, tiring and taxing times and eventually ace them too.

Poster Presentation

Enhancing 'Music: What it means?' LU teacher notes through pedagogic interactions & feedback

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Enhancing 'Music: What it means?' LU teacher notes through pedagogic interactions & feedback

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Introduction: Vigyan Pratibha Learning Units (LU) are modules on topics closely related to school curricula, but expose students to wider dimensions of science and mathematics. The teacher version of LUs have additional notes to help teachers facilitate these units in class. LUs are constantly reviewed: teachers' feedback in workshops, learning from practice sessions at school and reflections are used to enhance its contents. During the pandemic, we conducted Vigyan Pratibha online Discussion Seminars (VPDS), for teachers to discuss various LUs. To date, 100+ sessions are conducted and over 150 teachers have participated in it. The present work is an attempt to share how discussions on 'Music: What it means?' LU were studied in a team, with an objective to enhance LU content and prepare teacher notes.

Interaction during session	Musical Background	Enhancing the LU content	Interaction during session	Mitigating Practical Challenges	Enhancing the LU content
<p>Instructor provided a brief introduction about basics of music for novices</p> <p>Reasons articulated</p> <ul style="list-style-type: none"> Science teachers discussed hesitation to conduct this LU thinking they had no background knowledge of music. This LU can be conducted with the help of the music teacher, but getting some familiarity between concepts of science and music can be helpful. 	<p>12 musical sur : 7 are white keys, remaining 5 are black keys.</p>	<ul style="list-style-type: none"> Definition of terms common in Music & Science (volume, pitch, note, tempo) in teacher notes. Devnagri versions of musical terms (Note - स्वर, Tempo - लय) for building familiarity with music. Brief note about existence of 12 musical sur instead of only 7. 	<p>In Music LU, corresponding frequencies for all harmonium keys are to be noted. Practically, it is challenging due to background noise and sensor sensitivity. Instructor demonstrated these practical issues in the session.</p> <p>Discussion of using open-source smartphone application - <i>Arduino Science Journal</i> to record, store and utilize information about frequencies.</p>	<p>While taking observations, gauging the practical conditions (eg. background noise etc.) is necessary. Some general guidelines to depict this challenge & suggestions to improve observation quality were added in teacher notes.</p> <p>Step by step written guide for data collection and analysis was included in the LU.</p>	<p>Keeping in mind the present remote learning scenario, we have included some links to virtual piano/harmonium in the LU for open exploration. More tests to check its feasibility are under progress.</p>

One is supposed to find patterns from frequency table. Teachers often find difficulties in beginning this task.

MATHEMATICS	Keys	W1	B1	W2	B2	W3	W4	B3
<p>Some patterns are easily identified, while some, although important, may not occur immediately.</p> <p>We included teacher notes stating some common patterns which are likely to be observed by students, as well as important patterns which should either emerge out with more attention, else teachers can nudge the discussion towards it.</p>	Frequency	66	70	74	...			
	(in Hz)							

Examples of patterns shared by teachers.

- IT IS INCREASING (00:31:48)
- B1 b6 b11 b16 are double of the previous ones (00:33:09)
- W1 W2 W3 IS INCREASING IN STEPS OF 8 (00:34:00)
- ROUGHLY (00:34:18)
- W1 W8 W15 W22 DOUBLES THE PREVIOUS (00:35:01)
- W1 W2 = 8 W8 W9 = 16 (00:42:11)

After identifying patterns, one must try to represent them mathematically. This is a new concept for higher secondary class students, and may require teacher's support.

ratio (w8/w1, w15/w8, w22/w15) is 2 (00:37:23)

difference + 1 (00:40:14)

W3 TO B3 - DIFF OF 5 (00:40:30)

w1-w2, w2-w3 etc difference is increasing, also for b1-b2, etc. (00:41:34)

W1 W2 = f (00:50:05)

W22 W25 = 2 (00:57:58)

Excerpts from the discussion session.

Instructor: Can we mathematically predict the ratio based on the observed patterns? Taking the first frequency as f, and the common ratio as r, what will be the 2nd frequency?
Teacher 1: f.r
Instructor: What about the third one?
Teacher 2: f.r²
Teacher 3: f.r³

Instructor: If we take the frequency of W15 as f, what will be the frequency of W22 according to our previous discussion?
Teacher 3: f.r⁷



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Arduino Science Journal application

Acknowledgements - This work is carried out under Vigyan Pratibha Project. We acknowledge the support of the Govt. Of India, Department of Atomic Energy, under the Vigyan Pratibha Project (No. R&D-TFR-0650). We would like to acknowledge the Music Learning Unit author **Prof. Aniket Sule** for his continuous feedback during the development of teacher notes. Thanks to VPDS participant teachers and VP team.

Developing teacher notes for Archimedes Principle Learning unit: recycling interactional data

Pankaj Tadakhe, Amish Parmar, Sushma Rawool, Deepa Chari,
Homi Bhabha Centre for Science Education, Mumbai

Developing teacher notes for Archimedes Principle Learning unit: recycling interactional data.

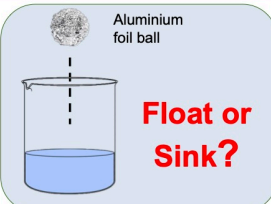
Pankaj Tadakhe, Amish Parmar, Sushma Rawool, Deepa Chari
Homi Bhabha Centre for Science Education, TIFR, Mumbai.

Vigyan Pratibha (Learning Units and teachers workshop)

Vigyan Pratibha Learning Units are educational content developed to discuss Science and Mathematics concepts in an engaged way with interested students. The Learning Units (LUs) also involves rich pedagogical discussions of science and mathematics learning and teaching. In its teacher version. These units are improvised/reviewed based on feedback from fellow teachers, experts in the field and researchers. Teachers workshop is one such place for seeking feedback on various learning units.

Vigyan Pratibha Teacher workshops are camps at HBCSE and/or partner institutes where teachers from various schools participate in training and development activities in mathematics and science and discuss pedagogic strategies. Such teacher camps have been useful for much needed feedback from the active teaching community in case of enhancing the Learning Units. The work presented in this poster is one such example where we have closely observed teacher interactions about the Archimedes Principle learning unit at one such workshop and used the interactional analysis to develop teacher notes content for this LU. It is an exemplar practice that can be used for similar note-making exercises.

Predict Exercise



Float or Sink?


“Will it sink or float?” discussion at workshop

“Lighter will float and heavier will sink” was a common response (and misconception) narrated by students & some teachers. So, it is important to address this idea through discussions. A probe to discuss and verify students’ beliefs about buoyancy is needed.

Addition to Teacher notes

Contrasting aluminium foil ball with a lighter object (stone/sand particle). A counterexample can help to question their prior belief about *lighter will float*.

Variables and Constants



Task

- ☐ Press the aluminium foil sphere into a disc. Observe whether the foil floats or sinks.
- ☐ Comment on the transformation from the sphere to disc.

Excerpt of teacher interactions

Facilitator: What is the difference here? First it[ball] was floating now why it[disc] has sunk?

Teacher1: Weight is same!

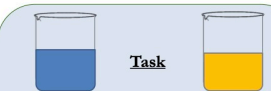
Facilitator: Then what difference has come. If you compare it to the ball(aluminium)?

Teacher2: Volume has changed

The idea of variables in a experiment

- ☐ The task required changing of one variable while keeping the others constant and studying the affect on the quantity measured.(mass was kept fixed, volume was varied).
- ☐ A note on “how experimentally the dependence of a quantity on certain parameters is studied” was included in the teachers notes.

The Challenges



Task


- ☐ Dip the aluminium disk in liquids with different density (plain water, salt water, oil etc) and observe whether the aluminium disk sinks or floats.
- ☐ Observe and measure the dependence of upthrust on density of liquid.

The experiment

In initial experimentation, visible(clearly identifiable) affect of density change were not quickly observed by teachers. Teachers hence continued trials with a)increasing salt concentration b) changing volume of the disc till they could satisfactorily observe effect of density on upthrust as theoretically expected. Theses trials provided a range of settings(conditions) where the effect was clearly observed.

Description for optimum conditions to observe the effects of density changes

A note about optimum a) concentration of the liquid b) the volume of the liquid c) volume of the disc to satisfactorily observe effect of density on upthrust was added.



VIGYAN PRATIBHA
विज्ञान प्रतिभा

Acknowledgements: This work is carried out under Vigyan Pratibha Project. We acknowledge the support of the Govt. of India, Department of Atomic Energy, under the Vigyan Pratibha Project (No. R&D-TFR-0650). We would like to acknowledge Joseph Amalnathan, Tripti Bameta, K. Mashood ,V Katdare, Ankush Gupta and the entire Vigyan Pratibha team for their support. Thanks to Tripti Bameta, K. Mashood and Ankush Gupta for extended interactions.

Use of Technology in conducting Science Experiments

Ms. Krishna Priya Ratheesh, Podar International, CBSE, Nerul

Introduction

“The Science of today is the technology of tomorrow”. This quote is exactly true and can be well related with the current situation. Due to the Covid pandemic, the education system has changed dramatically with the distinctive rise of e-learning, whereby teaching is conducted remotely in digital platform. With this sudden shift from the physical classroom to virtual mode we may expect that the adoption of online learning will continue in the post-pandemic situation as well. Despite the overwhelming consequences of the pandemic, this global crisis has also been an extraordinary time for learning. Having faced this new change, countries including India have combined high tech and low tech approaches to help teachers get better support in student learning.

As universities move classes online, some Science disciplines can have transition from physical to virtual classroom more easily than others. As we all know that science requires the demonstration of live experiments which increases the understanding of the students in various ways. The observations made and the conclusions of each experiment are important to be analyzed and then studied in order to create a greater level of understanding of a student. Physics, Chemistry and Biology being the three main streams need proper demonstration of experiments to make learning of Science fun. Here are some ‘out of the laboratory’ options for educators to consider as far as the online platforms are considered.

Use of Technology in conducting Science experiments

“Tell me and I forget .Teach me and I remember. Involve me and I learn”. Practical Science activities have huge significance in the learning process. They engage students and help them to develop important skills. Here are some technologies which will enhance the teachers to conduct Science experiments virtually.

1. Virtual Laboratories

Virtual experiments provided through interactive computer-based simulations has proven to have a positive impact on students' evolving skills, attitudes and conceptual understanding. Students normally engage in hands-on activities which are directed towards increasing their understanding and provide an insight into the principles involved. Virtual experiments have many advantages for laboratory instructions which include portability, safety, cost-efficiency, minimization of error, flexibility and rapid data displays. Olabs is one of the most useful virtual lab to conduct the school practical.

However, the idea of applying virtual laboratories in regular schools faces a set of obstacles and challenges such as the lack of tools, devices, large number of students in a classroom, privacy and security requirements etc.

2. Interactive CDs

Interactive CDs can feature video clips on Science experiments. The students will learn how Science experiments are conducted and the general rules of performing an experiment along with the observations that are featured. These video clips will also motivate and increase the interest of the students to learn Science. The learning can be enhanced by introducing pop-up questions and multiple choice questions that probe the students to think and test their understanding. However there will be lack of teacher student interaction.

3. Online Tutoring on Science Experiments and Projects

Online tutoring on Science projects and experiments is a great way to provide personalized help to students. A teacher or a tutor can work with the students in each step and brainstorm in constructing the projects or experiments. Online tutoring using an e-learning platform can also help the learning process and sharpen critical thinking skills in students through active discussion. It enables tutors and learners to bring the face to face interaction in a virtual environment.

There are possibilities of distractions due to poor internet connectivity

or inaccessibility. Online tutoring requires more discipline and it is difficult to answer everyone's queries.

4. Home Experiments / Self built Experimental Projects

There is a need to engage learners in physical actions and social negotiations in learning Science. Home experiments using common household materials and equipment have been suggested as an alternative to physical laboratory experiments. This method of conducting Science experiments is highly creative, productive and provides opportunities for creativity, develops manipulative abilities and brings conceptual clarity.

If the students are performing the experiments, there may be a concern of safety measures due to the absence of supervision. The child may not get a timely guidance on observation and conclusion.

5. Soft copies of Student Support materials

The student support document on Science experiments has a vital role in helping the students to go through the materials required, Procedure, principles involved, Observation Table, Conclusion or Inference. The Central Board of Secondary Education has designed an alternative activity sheet for grade 9 and 10 Science practical work dated 29.10.2021. The CBSE has curated a set of alternate experiments using simple and readily available household materials that learners can use to do these activities. These hands-on activities are accompanied by step by step guidelines, videos and worksheets for students to record the observations. The details are available on the Diksha Portal. CBSE provides an online training to teachers on the usage of these activities. Since it is a part of asynchronous learning, the student will get only partial knowledge of the particular experiment.

6. Recommendation of reference sites

The recommendation of different sites of Science experiments promotes a fair and appropriate use of knowledge from all scientific fields in a responsible manner. It is easy to navigate most important infor-

mation on the desired experiments.

The difficulty to navigate the right source and assessment of results of experiments are the key challenges that the students might encounter when they browse through different sites .Sometimes it will be difficulty for the users to get the relevant content.

As we all know a coin has two sides, similarly we have seen the pros and cons of various technologies used to conduct Science experiments. Thus the Education department should develop a strategic plan to overcome these challenges of teaching learning process. We will be able to use different technologies and online tools to conduct Science experiments which in turn enable to create a group of talented students and scientists.

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Learning loss in science and mathematics during pandemic

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Boraj

It shows that the impact of the pandemic on school student learning was significant, leaving students on average five months behind in mathematics and science by the end of the school year. The pandemic widened pre-existing opportunity and achievement gaps, hitting historically disadvantaged students hardest. In math, students in majority Black schools ended the year with six months of unfinished learning, students in low-income schools with seven. High schoolers have become more likely to drop out of school, and high school seniors, especially those from low-income families, are less likely to go on to postsecondary education. And the crisis had an impact on not just academics but also the broader health and well-being of students, with more parents extremely concerned about their children's mental health. The fallout from the pandemic threatens to depress this generation's prospects and constrict their opportunities far into adulthood. The ripple effects may undermine their chances of attending college and ultimately finding a fulfilling job that enables them to support a family.

Federal funds are in place to help states and districts respond, though funding is only part of the answer. The deep-rooted challenges in our school systems predate the pandemic and have resisted many reform efforts. States and districts have a critical role to play in marshaling that funding into sustainable programs that improve student outcomes. They can ensure rigorous implementation of evidence-based initiatives, while also piloting and tracking the impact of innovative new approaches. Although it is too early to fully assess the effectiveness of postpandemic solutions to loss of learning, the scope of action is already clear.

As the new academic year began during pandemic, Students faced multiple schedule changes, were assigned new teachers midyear, and struggled with glitch in internet connections and Zoom fatigue. This was a uniquely

challenging year for teachers as well as students, and it is no surprise that it has left its mark on student learning, and on student well-being.

As we analyze the cost of the pandemic, we use the term “loss of learning” to capture the reality that students were not given the opportunity this year to complete all the learning they would have completed in a typical year. Some students who have disengaged from school altogether may have slipped backward, losing knowledge or skills they once had. The majority simply learned less than they would have in a typical year, but this is nonetheless important. Students who move on to the next grade unprepared are missing key building blocks of knowledge that are necessary for success, while students who repeat a year are much less likely to complete high school and move on to college. And it’s not just academic knowledge these students may miss out on. They are at risk of finishing school without the skills, behaviors, and mindsets to succeed in college or in the workforce. An accurate assessment of the depth and extent of unfinished learning will best enable districts and states to support students in catching up on the learning they missed and moving past the pandemic and into a successful future.

Unfinished learning did not vary significantly across grades. Despite reports that remote learning was more challenging for early students, our results suggest the impact was just as meaningful for older elementary students. We can hypothesize that perhaps younger students received more help from parents and older siblings, and that older students were more likely to be struggling alone. While all types of students experienced loss of learning, some groups were disproportionately affected. Students of color and low-income students suffered most. Students didn’t just lose academic learning during the pandemic. Some lost family members; others had caregivers who lost their jobs and sources of income; and almost all experienced social isolation. These pressures have taken a toll on students of all ages. Many parents are very concerned about their child’s mental health, with a similar proportion worried about their child’s social and emotional well-being.

The impact of unfinished learning on diminished student well-being seems to be playing out in the choices that students are making. Some students have already effectively dropped out of formal education entirely.

The cumulative effects of the pandemic could have a long-term impact on an entire generation of students. Education achievement and attainment are linked not only to higher earnings but also to better health, reduced incarceration rates, and greater political participation. We estimate that, without immediate and sustained interventions, pandemic-related unfinished learning could reduce lifetime earnings. These costs are significant, especially for students who have lost more learning.

Opening buildings safely is hard enough, but encouraging students to show up could be even more challenging. Some students will have dropped out of formal schooling entirely, and those who remain in school may be reluctant to return to physical classrooms.

It was observed during day to day learning that students were not that enthusiastic to attend online classes due to which the loss of mathematics and science subject during pandemic was severe. After reopening of schools it was observed that many students were unable to apply basic mathematical operations as well as they were unable to recall basic scientific terms required for understanding academic syllabus of current year. Those students were active during online classes, they didn't find such problems during offline learning. During offline learning the activities were performed by the students and teacher acted like a facilitator to teach basic mathematical or scientific concepts using several activities whereas during pandemic as well, to get the subjects understood in a better way many audio visual techniques were adopted for students' academic.

ऑनलाइन शिक्षणामध्ये विज्ञान विषय शिकवण्यास येणाऱ्या अडचणी व त्यावर केलेली मात

प्रविण कांतिलाल रोठे, न. मुं. मनपा शा. क्र. 41, अडवली-भूतावली.

नवी मुंबई महानगरपालिका शाळा क्रमांक 41 अडवली-भूतावली या शाळेत इयत्ता चौथीच्या वर्गातील विज्ञान विषय शिकवण्याची जबाबदारी माझ्याकडे होती. सन 2019-20 व 2020-21 या शैक्षणिक वर्षामध्ये सन 2020 च्या फेब्रुवारी पर्यंत विज्ञान विषय शिकवण्याच्या प्रात्यक्षिकासहित काम चालू होते. परंतु मार्च महिन्याच्या मध्यानंतर कोरोना या संपर्कजन्य रोगाचा प्रादुर्भाव जास्त वाढत असल्यामुळे भारत सरकारच्या माध्यमातून देशभर लॉकडाऊन सुरू झाले. या काळात संपूर्ण देशाचे व्यवहार पूर्णपणे बंद झाले तसेच नेहमी किलबिल करणारी शाळा बंद झाली व देशभर सुरू असणाऱ्या लॉकडाऊन मुळे विद्यार्थी खऱ्या अर्थाने शिक्षणापासून वंचित झाले.

विद्यार्थी शाळेपासून दुरावल्यामुळे सर्व शिक्षकांसमोर विद्यार्थ्यांना शिकवण्याचा प्रश्न उभा राहिला. काय करावे हे सुचत नव्हते. अशा वेळेस डोळ्यासमोर एकच उत्तर मिळाले ते म्हणजे ऑनलाईन शिक्षण होय. पण ऑनलाईन शिक्षणामध्ये एक मोठा प्रश्न होता तो मोबाईलचा. शाळा सुरू असताना इयत्ता आठवीच्या वर्गातील विद्यार्थ्यांचा एक व्हाट्सअप ग्रुप बनवला होता व त्या ग्रुपवर नेहमी घरचा दिला जाणारा अभ्यास दिला जायचा. ऑनलाईन अध्यापनामध्ये एक प्रश्न होता तो म्हणजे पालक वर्ग विद्यार्थ्यांस मोबाईल देण्यास तयार नव्हते.

आमची शाळा क्रमांक 41 ही आदिवासी पाड्यावर असल्यामुळे तिथे पालक वर्ग हा कामगार आहे. बहुतेक पालक हे उत्तर प्रदेश बिहार या राज्याचे असल्यामुळे त्यांचे मोठ्या प्रमाणात स्थलांतर झाले होते. जे पालक गावामध्ये वास्तव्यास होते त्यांच्याकडे मोबाईल ची सोय नव्हती. इयत्ता पाचवी ते आठवी या वर्गातील ज्या विद्यार्थ्यांकडे मोबाईल नव्हते अशा विद्यार्थ्यांची यादी बनवण्याचे काम त्या त्या वर्ग शिक्षकाने पूर्ण केले. विद्यालयात ऑनलाईन पुरस्कृत विज्ञान विषयाची विद्यार्थ्यांना आवड निर्माण व्हावी म्हणून स्टीमलॅब दिली आहे. ह्या लॅब माध्यमातून आमच्या 30 विद्यार्थ्यांना टॅब चे वाटप करण्यात आले. स्टीमलॅबच्या शिक्षकांनी तो टॅब कसा वापरावा यासंबंधीचे मार्गदर्शन विद्यार्थ्यांना दिले व त्यानंतर खऱ्या अर्थाने ऑनलाईन शिक्षण सुरू झाले. इयत्ता आठवीच्या वर्गाची विज्ञान विषय शिकवण्याची जबाबदारी माझ्याकडे होती. शाळेत ऑफलाईन च्या काळात प्रात्यक्षिक स्वरूपात पाठातील मुद्दे व प्रयोग विद्यार्थ्यांस शिकवण्याचा प्रयत्न असायचा, पण ऑनलाईन मध्ये मोठा प्रश्न उभा राहिला. विद्यार्थ्यांना पाठाचे जर स्पष्टीकरण करून दाखविले तर समजण्यास अडचणी येतील याची पुसटशी कल्पना मला होती. विज्ञान विषय हा प्रात्यक्षिक स्वरूपाचा असल्यामुळे आता काय करावे हे काही समजत नव्हते. मग एक गोष्ट लक्षात आली की पाठातील महत्त्वाचे मुद्दे व प्रयोगच विद्यार्थ्यांना शिकवायचे. जे प्रयोग विद्यार्थी घरी अगदी सहजपणे करू शकतील ती कृती ऑनलाईनच्या माध्यमातून समजावून द्यायची व तो प्रयोग विद्यार्थ्यांस करण्यास सांगावे, जेणेकरून विद्यार्थ्यांस प्रयोग करता करता ज्ञान मिळवण्यास सोपे जाईल. विज्ञान विषयाचे अध्यापन करत असताना पाठातील जे मुद्दे, व्याख्या महत्त्वाचे आहेत त्या संकल्पना स्पष्टीकरण

द्वारे विद्यार्थ्यांस समजून देण्याचा प्रयत्न केला गेला. या कामी जरी 100 टक्के यश मिळाले नसेल पण विद्यार्थ्यांची विज्ञान विषयाची आवड आम्ही सांभाळू शकलो याचे आम्हाला समाधान आहे.

ऑनलाईन अध्यापन करण्यात प्रथम असंख्य अडचणी निर्माण झाल्या होत्या. परंतु विद्यार्थ्यांच्या पर्यंत मोबाईल किंवा इतर महत्त्वाच्या गोष्टी पोहोचवण्यास आम्हा शिक्षकांना विद्यालयाचे मुख्याध्यापक श्री. सावंत सर व स्टीमलॅबचे विज्ञान शिक्षक विक्रांत सर यांचे मोलाचे सहकार्य मिळाले. इयत्ता आठवीच्या वर्गातील सर्व विद्यार्थ्यांस गुगल अ‍ॅप च्या माध्यमातून विज्ञान विषय शिकवण्याचा प्रयत्न केला गेला. विज्ञान विषयातील प्रयोगाचे विद्यार्थी व्हिडिओ तयार करून ग्रुप वर पाठवायचे यावरून हा विषय शिकवण्यास आम्ही यशस्वी झालो हे आम्हा शिक्षकांना समजले.

Connecting Science And Society

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Introduction

Now peeping into the present scenario we can say that “Teachers” were given the challenging task of transferring their formal science classroom lessons to an online format at the onset of the COVID-19 pandemic. Now the question come how were teachers able to recreate student-centered science lessons online? And during these days what are the challenges did teachers face in teaching science online? The study revealed that how a group of teachers were able to maintain a science inquiry-based learning environment in an online format. Teachers revealed positive attitudes toward producing a scientific inquiry-based learning environment online, new opportunities for creativity in teaching science, and different perspectives on how teachers interact with students. And as we know that Science is an integral part of our knowledge-based societies; and is driven by societal concerns and teachers as a part of the society are responsible for and strive to provide meaningful educational experiences for their students. However, at the onset of the COVID-19 pandemic, and as schools began closing, teachers like an undefeated warriors without sitting by putting hand in hand fought bravely to do there duty honestly and in full fledge switch their own devices to determine how to provide similar meaningful educational experiences online.

Integrating social and scientific inquiries in class

As the disciplines like science that require a more hands-on, in-person educational experience have become a focus of concern, Specifically, in science classrooms and labs where equipment and technology necessitate in-person attendance, questions have been raised about how to emulate scientific inquiry practices in an online format.

The challenges and shared experiences will provide insight for science teachers, and general teachers alike, looking to better prepare themselves for

teaching in an online learning environment. Furthermore, the findings from the study will broaden the discussion of how best to implement science inquiry-based learning through an online learning format and examine what role might distance learning play in tandem with a traditional science classroom experience.

1. How to maintain a science inquiry-based learning environment in an online format?

Here we can say that Inquiry-based science adopts an investigative approach to teaching and learning where students are provided with opportunities to investigate a problem, search for possible solutions, make observations, ask questions, test out ideas, think creatively and use their intuition that fulfill **inquiry-based learning**.

2. What barriers were presented and how were they addressed in creating a science inquiry-based learning environment in an online format?

Challenges to inquiry-based teaching

- **Knowledge necessary for participation in democratic society**

Inquiry-based learning emphasizes having the learner to pursue investigations based on the immediate situation and personal experience. What is the guarantee that essential knowledge will be developed during the inquiry? This is especially the case for knowledge necessary to participate fully in a democratic society (Hirsch, 2006).

- **Cultural mismatch**

Inquiry-based learning may work for some learners, but others, especially those from marginalized groups need access to the societal codes for knowledge in a more direct fashion.

- **Lack of experiences to draw upon**

If learning has to draw on, build on, and be relevant to a learner's previous experiences, what happens when those experiences are

limited? Does everything have to be based on what you already know? If so, how is new learning even possible?

The importance of experiences implies that we find ways to incorporate richer experiences into learning. A related approach is to ask learners to critically engage with books, websites, and ideas that extend their world. Yet another is to expand direct experiences through field trips, service learning, nature study, or challenging problems.

- **Socio-scientific issues discussed in a technology-aided classroom**

Socio-scientific issues (SSI) are open-ended, multifaceted social issues with conceptual links to science. They are challenging to negotiate and resolve, and they create ideal contexts for bridging school science and the lived experience of students. It covers numerous topics like fish farming, genetic testing, global warming, and captive breeding in zoos etc. that address key themes for contemporary science education including scientific literacy, goals for science teaching and learning, situated learning as a theoretical perspective for science education, and science for citizenship.

Conclusion

However, traditional information sources plus many of the newer communication channels have multiple disadvantages. Peer-reviewed journals still monopolies scientist to scientist communication, but the technical language necessary for scientific rigor poses significant barriers to non-specialists. The blogs and social media accounts of scientists and institutions generally need to be individually sought out, and are at risk of being drowned out by the vast number of competing voices. Meanwhile, the mainstream media are prone to inaccuracies and sensationalizing stories to attract readers. In the absence of a source of factual, accessible scientific information, many people rely on the media for guidance on issues such as COVID-19. With the sheer number of news reports surrounding the disease, filtering out the superfluous narrative to find the facts that will help individuals protect

themselves and their families is extraordinarily difficult and keeping the mind steady and strong enough to analyses the current situation with scientific mindedness.

References

1. <https://www.scientia.global/the-importance-of-connecting-science-and-society-a-writers-view/>
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Conference Summary

The meeting started with greeting from Mrs. Mamta Agarwal followed by the welcome address of Dr. Bhagwat, Chairman NMSF. In his address, Dr. Bhagwat invited everyone to the meeting, described about decade long history of Science Utsav teachers conference.

Following was the Chitra Natarajan Memorial lecture delivered by **Prof. Arnab Bhattacharya**, Director HBCSE. Prof Bhattacharya took head on the most severe problem of practical science education with the spirit of home being the best laboratory in the time of pandemic. Home provides innumerable opportunities of science education when one keeps an open mind and scientific temperament was the motto of his talk which he demonstrated using a few examples.

After an introduction by myself, **Mr. Khurshid sheikh** the recipient of National Award for teachers talked on Science Eye that the young students should develop in order to learn and apply science and develop scientific temper. He described various programs that he implemented for students and teachers of his schools which could very well be adapted by many other schools as well.

There were four invited talks in two technical sessions.

In the first session chaired by Prof Savita Ladage, **Dr. Shirish pathare** talked about modern tools that are available for education. Beginning with a question of how well our laboratory education adapts to modern instruments, he described various modern devices that could change the way experiments are being carried out and taught in schools. Devices using hall probe, mobile based signal generators, manometers etc. are not formidably expensive these days, making a high technology education tool only an innovation away – was the carry away message.

In the following invited lecture **Dr. Alok Katdare** along with **Dr. Seema Lathkar**, spoke about Learning loss due to pandemic and online education. He described various ways of identifying and quantifying the loss of learning, he also described possible solutions to compensate such loss of

learning. They also suggested different assessment of those students who are learning online.

The second technical session was chaired by Dr. Reema Mani. **Dr. Dawood Vaid** in his speech mentioned that awareness is the tool to stop the slowing down of the education process due to pandemic. Leaning of the balance from 'choice of teaching' to 'choice of (self) education' by students, is the center point of the endeavor of Dr. Dawood.

In her wonderful lecture, **Dr. Aswathy Raveendran**, described the role of the trinity of Science, Technology and society. The technological advancements must be fueled by science and directed by society so that they stay on course for human development. The education and in-depth study of social issues generated by scientific knowledge and technological development, must be the hub of this activity for a peaceful global development said Dr. Aswathy. She elaborated on the development of scientific study of science education.

There were fifteen oral presentations.

In the fifteen contributed papers, teachers have discussed about the online education which is by itself a technological advancement. Ease of keeping record and sharing resources using social media has contributed immensely to the teaching methods. Virtual class rooms and computer based learning games that are available aplenty on the internet has influenced children's way of learning.

Audio visual is already known as an effective method of learning. Does the online class room has the advantage of the AV or does it pose problem of too much of screen time? - was question in the minds of many.

While online education could have some advantages of media, it also has some disadvantages like lack of attention due to non-supervision. Lack of human interaction and development of trust. Lack of social interaction among children etc. More over equal opportunity of accessibility is also an important issue to be addressed.

Contributors also discussed the differences in the assessment method and practical education etc.

In the case of laboratory education, the online simulated lab is very popular and probably a better tool for students of younger class. However, this method lacks or at least reduces exposure to the real devices. Examples of simulated experiments that improved the education values were also discussed.

Even on the online class, it is the teachers' ability to keep the focus and retain the attention of the students. The online methods for such a performance of a teacher may be different from the classroom methods. Facilitation means listening and aiding. Be with the problem to solve it. Be supportive to accommodate education as a comfortable part of a students' life. That is the role of a teacher as a facilitator. Facilitator also is happy about their students achievement.

Social justice like gender equality and accessibility to technology need also to be addressed for online education. Attendance trend was studied which brought up issues of attendance due to multiple children at home, loss of job of parents and relocation.

In addition, there were specific methods discussed as to how to use mobile and other devices for making the measurement more accurate in an easy way that the students find interesting.

Influence of language in science education was tried by translating various learning units of Vigyan Pratibha project in Marathi. In addition to challenges in converting the scientific terms, problems like gender specificity and cultural influence appeared as a problem in this translation project.

There were five posters:

1. Mathematics of music
2. Technology in conducting science experiment
3. Archimedes principle
4. Learning loss in online learning
5. Connecting Science and Society

Dr. A. K. Rajarajan