Developing Online Interactive Environment For Science Teaching and Learning

Proceedings of Online One Day Teachers' Conference

Science Utsav 2021

SATURDAY, 6TH FEBRUARY 2021

ONLINE ZOOM MEETING

Editors

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Homi Bhabha Centre for Science Education (TIFR), Mumbai

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ORGANISED JOINTLY BY

NAVI MUMBAI SCIENCE FOUNDATION, NAVI MUMBAI

HOMI BHABHA CENTRE FOR SCIENCE EDUCATION, MUMBAI

&

NATIONAL CENTRE FOR SCIENCE COMMUNICATORS, MUMBAI

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Saturday 6th February, 2021

Online Zoom Meeting

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Concept Note

Theme for Teachers' Conference 2021 (TC – 21)

Developing Online Interactive Environment for Science Teaching and Learning

The Covid-19 pandemic has brought before us unprecedented challenges. Education is especially disrupted due to the various lockdown and distancing measures in place. Many teachers and students across the country are struggling to cope with the challenges while keeping teaching and learning alive. The challenges are great in science teaching as it involves working with materials and experimentation and observation. At the same time, the problems in making use of technology not only to attend school but to share their work/ ideas has not been easy for students.

A conference aiming to voice the challenges, efforts, and innovations that teachers have been undertaking to achieve successful science teaching is a need of the hour. Therefore, we announce a conference that engages with teachers, principals, and parents on "***Developing an online interactive environment for science teaching and learning".*** This theme will help collate various ideas and resources that have emerged in this pandemic to cope with online teaching-learning, as well as provide a platform for our science educators to present their topic-specific challenges.

Teaching remotely is conducted in two ways – in the synchronous mode where teachers and students interact in real-time through conferencing tools or asynchronously, where learners are given access to resources and recorded lessons. While these modes create huge opportunities for learning they also require educators to reflect on more interactive pedagogy, which can support learners in creative and imaginative ways.

Sub-themes

1. Tools for Interaction in the Online Mode: Teaching remotely in the synchronous mode where teachers and students interact in real-time through conferencing tools, various new resources have been used by teachers. The choice and appropriate use of tools would significantly impact the teaching-learning process. Share your experiences about the tools that helped in making the online classes more interactive, meaningful, and ensured greater student participation. Also, describe the use of specific features of the technological tools that played a key role in leading active interactions in the online mode (e.g., screen sharing, a common blackboard, and other blending features).

2. Planning and Designing for Online Science Teaching: Whether it is teaching online or recording your videos of teaching, a description of the planning and designing measures in specific contexts would be helpful. You can bring in examples from your planning in the context of varied science topics to make these descriptions meaningful and have impact.

3. Scientific Temper in the Online Class: One of the aims of science teaching is to help develop critical thinking and scientific temper among students. How this aim is focused on in online classes can be the subject of discussion with examples.

4. Challenges in Teaching Science in the Online Mode: In the traditional teaching, prior to pandemic, the use of digital technology has been largely lacking, and if used, perhaps did not actively engage the student. Since the onset of the pandemic, schools have been forced to explore remote teaching and teachers have had to conduct their lessons through conferencing platforms. The specific challenges you and the students faced while transitioning to the online mode are of significant in understanding various ways in which teacher and learner support can be shaped. Are there specific concerns that are still not addressed? A description of your efforts in changing attitudes and dispositions towards online teaching will help teacher educators to develop better support for the future teachers. Similarly, if specific considerations for interpersonal skill development and equitable participation are made in the online mode, it will be useful knowledge to share within the teacher community.

5. Science Experiments and Online Teaching: Experiments are synonymous with learning in science. Lack of infrastructure and appropriate devices for making science accessible to students has always been a major challenge. How did teachers make this possible in the online mode? Describe your successful and not-so-successful attempts on this specific aspect of science teaching and the experiences thereby that will be useful for other educators. Also, share how these online environments enabled students to explore scientific phenomena consistent with scientific practices.

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

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Navi Mumbai Science Foundation		
Science Utsav Teachers' conference 2021 - Program		
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10:15 - 10:20	**Release of Proceedings**	By Chief Guest
10:20 - 10:50	**Session - I: Chitra Natarajan Memorial Lecture**	**Chair: Dr. G.P. Kothiyal**
10:20 - 10:22	Introduction of Dr. Shweta Naik	Dr. A.K. Rajarajan
	Chitra Natarajan Memorial Lecture	Dr. Shweta Naik
10:50 - 11:05	Felicitation of President Awardee	By Chief Guest
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	Awardee's speech	Ms. Sangeeta Sohni
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Editorial

Developing Online Interactive Environment for Science Teaching and Learning

The Covid-19 pandemic has brought before us unprecedented challenges. Education is significantly disrupted due to the various lockdown and distancing measures in place. Many teachers and students worldwide are struggling to cope with the challenges while keeping teaching and learning alive. The challenges are significant in science teaching as it involves working with materials and experimentation and observation. Simultaneously, the problems in using technology not only to attend school but also to share their work/ ideas have not been easy for students.

This conference aims to voice the challenges, efforts, and innovations that teachers have been undertaking to achieve successful science teaching is a need of the hour. Therefore, we announce a conference that engages with teachers, principals, and parents on "***Developing an online interactive environment for science teaching and learning".*** This theme has helped collate various ideas and resources that have emerged in this pandemic to cope with online teaching-learning and provide a platform for our science educators to present their topic-specific challenges.

Teaching remotely is conducted in two ways – in the synchronous mode, where teachers and students interact in real-time through conferencing tools or asynchronously, where learners are given access to resources and recorded lessons. While these modes create enormous learning opportunities, they also require educators to reflect on more interactive pedagogy, supporting learners in creative and imaginative ways.

These proceedings report several innovative strategies that the teachers have used during this pandemic. Besides knowledge of different technological interventions such as google classroom, flip classroom, zoom team, Quizlets, 3-D animation or modelling, etc., teachers have generated innovative ways to keep the core of science teaching alive. You will find papers that describe home gardens, kitchen practicals, detailed process of making videos for science learning, development of explanation map, etc. These proceedings show our teachers' adaptation skills and remind us how intellectually strong our teacher community is! The amount of work gone under their efforts to move from blackboard to screen share is highly commendable.

We congratulate all the authors whose work has been accepted in these proceedings. As editors, we have taken efforts to highlight the scholarly aspect of these teachers' work and yet tried to maintain the soul of their original grounded approaches.

Shweta Naik

A. K. Rajarajan

5th Feb 2021

A Note on Navi Mumbai Science Foundation (NMSF)

(An NGO's portal for innovation in Science Education)

Navi Mumbai Science Foundation (NMSF) is a science led NGO located Navi Mumbai, India. It is dedicated to development of "scientific temperament " in the society in general & the student community in particular. This in turn contributes towards the holistic development of 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 well defined action plans.

ACTION PLANS

- **Develop a network of professionals and personalities** to share their knowledge for the benefit of upcoming generation. To this end we have started an educational magazine EduREKA oriented towards young students
- **Provide multi-disciplinary environment to students** to understand their inter linkages through activities like guidance for Homi Bhabha Bal Vaidnyanik Competition and guided educative and creative scientific projects as playful and fun filled activity.
- **Provide a platform for interaction between leading educationists, teachers and students**. Science Utsav Teachers' conference is the pinnacle of such activity which brings scientist, scientific educators and teachers together.

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

I. Interactive Guidance Sessions for "Homi Bhabha Bal Vaidnyanik Competition [HBBVC]" with Scientists & Research Scholars.

II. Science Nurture Club Activity (syllabus-based theory lessons & science-based project work) for students of Std. VII & VIII (separate Batches).

III. Guidance Sessions for "Regional Mathematics Olympiad (Pre-RMO & RMO Exams)".

IV. Essay Competition on the topic "Nurturing Talent for Noble Laureatism

V. Fun with Science Programmes (as per request from schools).

VI. Special Event: World Nuclear Energy Day celebration (Dec. 2, each year).

VII. Signature Event of NMSF: Science Utsav (a two-day event)

VIII. National Science Day celebration (Feb. 28, at KBP college & at some schools as per convenience)

IX. Providing Judges for Science Exhibitions at schools & colleges (as per request).

X. Participation in Miscellaneous Scientific Activities at schools & colleges (as per request).

XI. A quarterly scientific E-Magazine for students of Std. VI to X, under the name "EduREKA".

XII. Dr. Vikram Sarabhai Essay Competition on the general topic "Space Exploration" – introduced during the academic year 2020-2021.

XIII. National Mathematics Day celebration (Dec. 22, each year, at KBP College).

XIV. International Mathematics Day celebration (March 14, at KBP College, proposed during this year).

Why NMSF?

Activities of NMSF involve students of the **age group of 10-17 years, which are the most formative years in the life of any individual.** This in turn contributes towards a holistic development of the nation and prepares it to face the challenges posed by a technologically advancing global environment without losing sight of its societal commitments. **In due course, NMSF wishes to identify itself as an NGO's portal for innovation in Science Education.**

It is essential here to understand why NMSF thinks this way. In the beginning, we asked ourselves questions like i) a need for existence of an organisation like NMSF ii) specific role of NMSF and iii) how its activities will meet the societal needs of the day. While pondering over such questions, **we also reminded ourselves that India has become a parched country as far as the count of homegrown Nobel Laureates in science is concerned.** The last Indian Nobel Laureate in science stream was seen on the world stage in the year 1930. What happened thereafter?

Time was therefore ripe to review the scenario in retrospect, then introspect & come out with a feasible solution without getting lost in a blame game of any sort. While doing so, we kept in mind that India too had a rich past in scientific achievements in the fields like Mathematics, Astronomy, Medicine & Metallurgy which covered India with glory for more than two millennia before the 12^{th} century AD. Revival of the past glory should not, therefore, prove to be an insurmountable challenge.

In the years after independance, emphasis in education was on lateral growth. The stress here was so intense that vertical growth took a back seat – i. e. growth of centers of excellence in science & technology became a casualty. The real talent, therefore, started migrating in search of greener pastures & the trend still continues.

To reverse this trend, adequate world class R & D opportunities in basic sciences must become available in India too – sooner the better. It is this effort which will provide the real platform for sound societal growth. **It will also encourage some good students to stay back and join streams in basic sciences & basic engineering where more satisfaction prevails in the long run.**

This is where the work of Navi Mumbai Science Foundation is expected to make an impact. The main plus point with NMSF is that it has been able to attract a few dedicated scientists from BARC who willingly interact with young students on a regular basis; the focal point of discussions being:

i) that part of science which lies beyond the four walls of the class room **and/or**
ii) that which is hidden in between the lines of the text books.

This has emboldened NMSF to have a **VISION** of its own which is purely pupil-centric and focuses on hands-on experience in science. The fortunate part of the entire exercise is that more & more parents are appreciating such efforts and are sending their children to take part in the activities being organised by NMSF.

A.M. Bhagwat
Chairman
Navi Mumbai Science Foundation

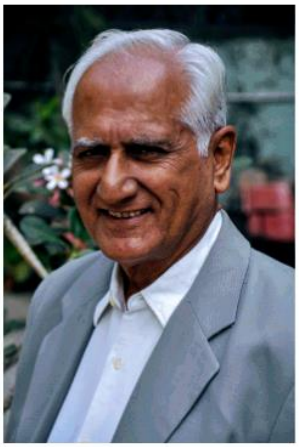
Our Website: ***http://www.navimumbaisciencefoundation.org***

Chief Guest's Speech

Convert the calamity into opportunity

A. P. Deshpande

National Centre for Science Communicators



Nobody's life is a straight line graph. Even in a sinusoidal graph the line moves from positive side to negative side, but have patience, this line from negative side enters into positive side again. I read one article recently that after 220 million years from now, entire life on earth will be topsy-turvy. So Kovid-19 has changed our life style isto be taken as an opportunity.

Before the arrival of British raj in 1818, all schools were ashram schools. In the olden days science subject like Ayurveda was also taught to 5-6 people at a time in Ashram shala. My father in 1925 studied Ayurveda like that in Girgaon, Mumbai. But when British raj started functioning, formal schooling as it is today began. They brought text books on line with England and ultimately mass education started. However looking to the population of educating students, the present number of school and colleges are insufficient. We could not get the solution to this problem as yet. We were trying to find out solution and in the meantime Kovid-19 pandemic spread its wings over the entire word. Skype, internet, zoom, goggle apps were in existence but were used very meagerly. In the pandemic preventive measurements suggested us not to assemble in schools, colleges, cinema and drama theatres, travel in buses, trains and aero-planes. Hence education came to standstill worldwide. There was confusion for first two months. Everyone was in fearful state. However, slowly people started thinking and goggle and zoom and many other apps came to our rescue. As I understand some schools started functioning right from April, 2020, though not as usual taking 6-7 periods, but 3 or 4 periods. And such schools are about to complete their year. However compared to entire school going population, this may be 3-4 %. It means major problem is yet to be tackled. Science education, for which we have gathered here, is still miles away. However whenever science periods were conducted in such schools online, diagrams, models, labs remained in schools under the lock and key and no one could enter the schools and yet the periods have to be taken. In such a situation, teachers worked till midnight to prepare all such teaching aids and yet they could

not provide the lab work. However, they gave lot of home assignments, but finding innovative ideas cannot happen overnight.

In some villages, enthusiastic teachers have started schools at open places for some students and for some time, using walls as blackboards. But again, this is a small fraction. So, now the idea is coming up that 50% students should attend the school on day one and remaining 50% on second day. Again first 50% on 3rd day and likewise. On the school days also 3 to 4 periods to be taken. It amounts to 25% curriculum can only be covered up. While starting schools in this fashion, students need to bring a consent letter from the parents and fearful parents are not prepared to give such consents.

Schools and colleges got closed from 20th March, 2020, almost 12 months ago. No final examinations could be held, no admissions to next year. So one year is lost from the life of most of the students. In the meantime new virus has entered from UK. Fortunately, it has not affected us notably, but bird flu menace is there.

So, in such a fluid situation, we have to depend on internet and that we are used to it during past 12 months. For science education, we have to depend more on videos and simulations. If possible, for botanical practicals. Let students go to neighboring garden and receive instructions on mobile phone. I remember, during 1990's All India Radio, Mumbai center had organized sky gazing programs through transistor. One needed to go on the terrace with transistor and receive instructions on radio, like look at East and see so and so constellation etc. This program was continued for quite some time.

For those, who cannot go to schools, should the classes be held like open airtheatre. Students should be asked to perform science experiments on the things available at home. Taking litmus paper in hand and using house hold liquids like milk, buttermilk, vinegar, lemon juice, water, phenyl, tomato soup, soda water, Coca-Cola and so on and see which one is acidic and which one is alcoholic. Let them see which are the things in the house based on the principal of lever and out of three types of lever, which one is that. Let them list out the electrical equipment in the house and measure usage of each of them in terms of minutes. At the end of month, find the total usage of each of the equipment in hours, multiply it by power capacity in kilowatts and find out the consumption in electrical units. Thereby one can make his own bill. If this exercise is started from the date of the bill, one can compare it with his bill. In the house, let the child take a magnet in hand and touch it to wooden door, glass, marble platform, door hinge, water tap, stainless steel utensil, brass utensil, copper utensil, silver utensil, golden ring, iron rod and so on

and find out which material is magnetic and which is not. In the potted pot, let him sow the coriander (धणे) and mustard (मोहरी) and watch the growth. Similarly taking three potted pots take in one red earth, in another black earth and in third, sand and sow mustard. Then watch the growth. In three bowls, take water to its 75% capacity and put in one common salt, in other sugar and in third alum powder, each one table spoon and dissolve them in water. Then keep them in sun and watch in how many days, the water evaporates and then how the crystals get formed. Likewise, many more house hold experiments can be done and it is enjoyment cum education.

Navi Mumbai Science Forum is working with rigor and seriousness for past 14 years is witnessed by me. I know Dr. Arun Bhagwat for years and have delivered few lectures on water conservation in some of the schools in Vashi few years back.

I congratulate NMSF for organizing such an innovative program for science teachers and give them a poser to think something innovative. Marathi Vidnyan Parishad hosted a National Teachers Science Congress on behalf of Central Government in 2015 at ISSER, Pune and then subsequently for state level science teachers for next four years along with IISER, Pune.

I wish NMSF and all the teachers present here a best luck in their endower.

Prof. Chitra Natarajan Memorial Lecture

What is this thing called Science?

Shweta Naik, Homi Bhabha Centre for Science Education, TIFR, Mumbai

Introduction

What is science? Science is a way to understand, explain, and predict the world. Many people believe that science's distinguishing features lie in the particular methods that scientists use to investigate the world. In this paper, we will figure out, traditionally what have been the ways of knowing for humans, and which of these provide scientific knowledge. We will discuss a couple of examples to understand what is a scientific approach to knowledge. Towards the end, we will provide a glimpse of what constitutes scientific method in modern days.

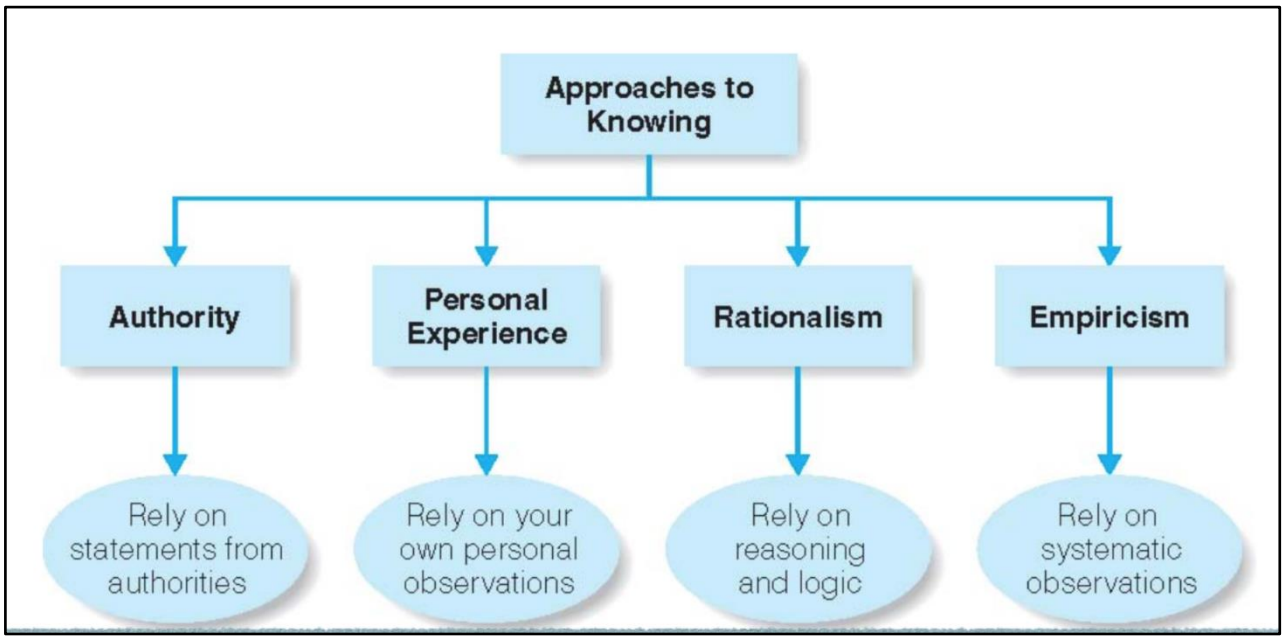
Approaches to Knowing

Every day in our lives, we are confronted with situations that necessitate making choices. How do we assess these situations, make decisions? Some problems that we encounter are emotional, but what about the questions pertaining to the world's functioning? How old is our earth? How does our respiratory system separate oxygen from other gases when we breathe in and out? When and how humans evolved? What curriculum should be taught in schools?

A more sensible answer to this question is that what we choose to believe may be based on integrating information from several sources. For example, how do you make sense if someone tells you drinking cow urine with turmeric cures cancer? Where does this belief come from, you wonder. Perhaps, your parents, teachers or some religious Guruji preached about it. Or maybe, you drank urine with turmeric and experienced some positive effects. Or you might have read about it somewhere, heard from your friends, but more realistically – you might form this belief integrating information from various sources. Information that is not questioned or empirically checked yet, possibly making it misinformation and NOT a scientific knowledge. What questions might one ask? More straightforward would be – what in the urine can impact cancerous tumours? When some scientists said that it does not have scientific evidence – what does it mean? What about its effects – like the amount of uric acid in it causing, obesity, insulin insensitivity, and hypertension? This example tells us there are several ways of knowing, but not all of them are scientific.

A.F. Chalmers in his seminal work, "what is this thing called science?" describes four approaches to knowing that we see relevant even today. Authority, personal experience, rationalism and

empiricism are four approaches that we use to know about everything we are and are surrounded in the world.



Authority: Conceivably, one of the most common approaches to knowing is through authority. It involves accepting new knowledge because some authority figure stated that they are correct. The authorities include parents, the media, doctors, religious and political leaders, and the government. Religious texts are one such example, where the method of authority is dogmatic, and no one is allowed to question any of its text. Science also experiences dogmatism when scientists believe so firmly in their asserted theories that they forget to problematize it for numerous possible contexts. In an ideal world, where authorities often represent the good of the people, one should be able to trust authority. However, historical lessons predict otherwise; many instances of atrocities against humanity are a consequence of people unquestioningly following authority (e.g., Nazi War Crimes). We often acquire information from authorities, as we do not have the time and resources to independently research every piece of knowledge. However, one needs to be conscious in developing conclusions based on such information, as authorities might have their own reasons to mislead us. In the contemporary context there is also discussion about dogma of scientific method. We often see advertisements that label products as scientifically proven; and saying something is scientific definitely doesn't make it that. On the other lines, Wivagg and Allchin (2002) also warn us about the dangers of seeing scientific method as one set of procedures.

Personal Experience: Often we all get insights from our personal experiences and observations that are unique to us. Professionals such as writers and artist, use these insights in their writing and works of art. Even though we often do not make our insights public, it contributes to the development of our beliefs. However, we must be careful. Our own experiences can lead to faulty beliefs and prejudices.

On the other hand, our intuitions developed based on our knowledge, believe in what feels true instead of examining facts or using rational thought. Weighing truth and thinking about different possibilities, all the time, could become transfixing, leading us to use our intuition. However, our instincts can be incorrect, driven by cognitive and motivational biases rather than logical reasoning or scientific evidence.

Rationalism: Rationalism emphasizes reasoning and logic rather than experience. However, the things are not crystal clear from here on, as even though rationalism opposed empiricism historically, they are not mutually exclusive. Reasoning and logic are powerful methods in the search for knowledge and understanding. Rationalism often begins with an assumption, often called preposition or a-priori belief, and concludes using logical deductions. For example, all crows are black, and you saw a crow, then it had to be black. It is a simplistic example of the rationalist argument, and one can easily see if the premise is wrong, then the claim will be incorrect. Descartes, Leibniz both rationalist supported reason over experience. Kant was the first philosopher who identified fundamental issues in rationalism and empiricism and argued that we need both reason and experience to obtain the truth.

Empiricism: Reasoning, personal experience, and authority are not enough for the empiricist. For empiricists, experiencing events through observations and stimulation of our senses (seeing, hearing, touching) is required. We are limited in what we can experience and observe. Also, our prior experiences can alter the way we perceive events. Therefore, science relies on structured observations and considers the fallibility of experience and does not search for universal or absolute truth.

In the current scenario, many of us have developed new ways of knowing, called WhatsApp YouTube universities. One can consider them as part of the media, although the level agency is much narrower here. As a society, we need a separate and much longer discussion about what it means to know and act based on these resources.

These approaches of knowing, makes us reflect on what is a scientific way of knowing, and also what can be scientifically investigated.

The Scientific Method

Most textbooks describe the scientific method as steps one needs to do to achieve a scientific conclusion. Wivagg and Allchin (2002) also warn us about the dangers of seeing scientific method as one set of procedures. They propose a concept of Scientist's toolbox, that includes "...hunches, clues, and questions obtained from observations, earlier claims, reading, etc. Scientists explore how to generate relevant information. They consider possible sources of error. They engage others in interpreting evidence. Results usually lead to more questions. Ideas are refined. Some change, some are abandoned." [SEP]

Among various aspects of the Scientific method we choose to describe two things in this talk– what phenomena are investigable and what are scientific observations.

Investigable Phenomenon: The event needs to have an empirical aspect – a component that can be experienced. The event must be observable or measurable, either directly or indirectly. For example, a subatomic particle is seen and measured by the trace it leaves on a photographic plate. Gravity is understood by its observable and measurable effects all around us. The construct of learning is measured in terms of its effects on some aspect of knowledge and behaviour. And therefore, events with no empirical referent (such as existence of ghost) are empirically inaccessible, and can not be investigated.

Observations: As we already discussed how an event for scientific investigation needs to have an empirical referent, make that event public and observations objective not subjective. The observations are repeatable, making others repeat the phenomenon and observe the effect. Repeatability of observations leads to a self-correcting science. As the observations need to be empirical and repeatable, scientific method develops a built-in self correction.

One needs to be careful in making distinction between observation and inference. In addition to digitally measured observations (measuring length, weight, density, etc.), observations are also made using senses, and therefore could be descriptive, quantitative or tactile. Inferences are conclusions based on the observations. Observations sometimes are tentative, making the scientific knowledge tentative in nature (lack of specific tools, methods for observation, etc.)

Making accurate observation therefore forms an essential basis for accurate science. However, this view is critiqued by Hodson (1985), who cites 15 philosophers that raise concerns regarding objectiveness of the observations. Observation might be subjective. There is the well-known idea of 'theory ladenness of observations'. Accordingly, statements based on observations are always made in light of one's existing ideas/concepts/theories and experiences. In this regard, observations will be subject dependent and theory dependent. This critic moves the focus from observations to the results, making the results' repeatability (under the same conditions) important.

The Scientific Inquiry

Newton-Smith (1981) has argued that there is no prescriptive method of science, as "a practicing scientist is continually making judgements for which he can provide no justification...". Therefore, it is essential to talk about the process that involves the scientific method—like, asking questions, observing, experimenting, inferring, making conclusions etc. This whole process is a social process, as there are many influencing factors. It depends on what sort of questions are being asked; who is asking those questions; what tools/instruments are used/available; and who is providing funds, etc. During the presentation we will see some of the reasoning methods that has undergone science inquiry.

Presentation Note:

In the presentation of these ideas, I will use examples from contemporary as well as historical works and elaborate these ideas further. We will see what are the goals of Science and how that impacts reasoning strategies. I will also discuss the idea of modern scientific method – from the positivist point of view.

Acknowledgement

Firstly, this write-up is not even close to completeness, there are several views on Science, Scientific Method and Science education that are needed for the holistic discussion of these topics. Given the time of presentation, I have attempted to touch base on some relevant ideas for teachers and students and will add more examples during my talk.

I sincerely thank my colleagues, Dr. Gurinder Singh, Mr. Sushant Pawar, Dr. Aaloka Kanhere and Dr. Aniket Sule for their help in refining some of these ideas.

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Invited Talks

Scientific Temper in Online Teaching

Dr. Rohini Karandikar, Homi Bhabha Centre for Science Education

In the present times, when plenty of information is freely available at the click of gadgets, we are being misled by the knowledge that is not scientific. Whether it is “not eating during eclipses” or “clapping hands because it kills the novel coronavirus”, we encounter a lot of false information every day and also pass it on! This raises questions on the views of our society being aligned with scientific temper.

Scientific temper is a way of life wherein we seek evidence for any new idea that is passed on as ‘scientific’.

How can we teach students to develop scientific temper in the online space? Can scientific temper be connected with the science curriculum? Can students make scientific temper their way of life?

Challenges in Teaching Science in the Online Mode

Kishore Darak, Manager, Education, **Tata Trusts**

With its global spread, the Corona pandemic has impacted every aspect of human activity across the world. Sites of formal education – anganwadis, schools, colleges, universities – are no exception to the unprecedented disturbance caused in terms of intensity and scale. For the first time since the conception of universal education in the modern era, schools in various countries remained closed simultaneously for long durations since January 2020. In India, schools were closed in mid-March 2020 and have started resuming only recently.

The simultaneous physical presence of a group of individuals, children and adults, at a common site of formal education, i.e. at school is an intrinsic assumption of modern-day educational activity. Given that the pandemic shook the very assumption underlying normal functioning of schools, online education was considered to be a way out from the grip of forced inactivity and a quick-fix response to the so-called new normal.

In India, where online connectivity and access to devices are far rarer compared to many of the eastern and western societies, online education, by its very conception and design, became exclusionary. Existing digital divide led to forced learning 'deficit' among students coming from diverse backgrounds posing a serious challenge to the ideals of equity, inclusion and social justice. But even when access to online education was available, the type of online resources and the way these resources were offered to the learners in mass drives by state machinery raised a lot of concerns. To name a few, these are quality of online content, processes of curating without any rigour, duration of engagement expected from learners, adult support and scaffolding expected in the process, financial and other costs of online learning.

On this background, I would discuss how the pandemic situation posed many challenges to education in general and how science education faced some specific challenges, including systemic neglect compared to language and math. By its nature, science education involves 'learning by doing' as an important pedagogical principle. Laws, rules and principles governing

natural phenomena, which science as a discipline endeavours to explore, can be arrived at or derived from guided activities undertaken in the science classroom. At higher grades, these activities assume the role of more serious ‘experiments’ or ‘lab work’. Some of the fundamental competencies in science learning like doing observation, comparison, hypothesising and inferring are nurtured through the personal involvement of the student in hands-on or lab activities. As such, due to various historical, cultural and economic reasons, Indian schools exhibit a tendency to bypass lab-work and rely only on teaching (read narrating) theory, dished out through the sacrosanct textbooks, as science education. The pandemic situation has multiplied this tendency. Schools known for meaningfully using well-equipped lab facilities got placed alongside schools bypassing lab-work. Observations and reports from teacher community suggest that during the current online times, at best, lab work is getting equated to watching online videos (mostly unregulated or not curated), peer interaction is getting equated to sporadic remarks in chat boxes, live interaction between teacher and students is getting equated to a long monologue by teacher and self-exploration is getting equated to browsing the internet with search engines. After discussing these and other challenges in teaching science in online mode, I will attempt to suggest measures for teacher development programmes and changing school ethos so that we are better equipped to face such situations in future.

Science Experiments and Online teaching

Snehal Choudhary, Physics Department, Abasaheb Garware College, Pune.

Throughout the school level, the aim of science education is to encourage curiosity and inquisitiveness, develop questioning abilities and problem-solving skills, acquire scientific knowledge, and develop a conceptual understanding of the natural world among students. From a teacher's point of view, science education focuses on effective ways of teaching and enabling learning of science and delivering appropriate instructions suitable to science as a discipline.

One of the overall aims of science education is the demystification of science for people at large, and that science should reach the masses and should be a part of everyone's life. Observing and explaining different phenomena in nature, in one's surroundings, drafting/ hypothesizing laws, and testing and validating them are some of the key blocks of teaching science. Testing a phenomenon can be done mainly by doing experiments. Thus experiments are integral in science teaching-learning.

The COVID-19 Pandemic has adversely affected education worldwide, particularly in developing societies like India. Teachers and students have faced multiple challenges as they were suddenly made to adapt to teaching-learning through an online mode. With limited and skewed access to digital infrastructure, the digital divide between the haves and the have- nots has glaringly come to the fore like never before. Further in situations where access was taken care of, experience shows that teaching theoretical aspect has been possible to some extent, but practical aspects such as teaching or doing experiments in science class have become virtually impossible or possible with very limited success at best.

This talk will focus on science experiments and how teaching the same was accomplished during the Pandemic. Based on my own experiences as a physics teacher at a higher secondary level, I will discuss the role of experiments in science teaching. After discussing briefly the centrality of science experiments in enhancing the students' understanding and skills. We will glance through teachers' methods to conduct, demonstrate, and teach science experiments in online mode and the challenges therein. With the help of teachers' and students' views about learning experiments online, we will try to understand the challenges and successes. Finally, we will discuss the scope of conducting experiments meaningfully in online mode and the ways to make them effective.

Reimagining Higher Education- Post Covid

Dr. Pushpinder G. Bhatia, Guru Nanak College, Mumbai

The COVID-19 pandemic is set to change the world in more ways than we can imagine. The Higher Education Sector is undergoing a tectonic shift. 'Edutech' (Education Technologies) is the biggest intermediary of the teaching-learning process. Many doubts about efficiency and effectiveness lurk as we are constrained to adopt the online mode of teaching.

An understanding of the limitations of online teaching will help us understand the problems that the digital landscape has brought. Covid has been an 'unequalizer' in most ways. The gap drawn by the availability of digital facilities is wider than ever before and challenges the core values of access and equity in higher education.

Education systems have an opportunity now to reimagine learning and equip students with creative, innovative and cognitive skills to navigate the future, as students will not re-enter the same classrooms that they left last year.

Contributed Papers

Issues and Challenges for Online Teaching of Pre-primary School Children

P. Vasundhara, Sunrise Montessori School, Navi Mumbai

Introduction

The corona virus disease (COVID-19) has been declared a pandemic by the world health organization. To limit the spread of the disease, many countries worldwide, including India, had enforced a lockdown.

Continuing education is important for the pre-primary stage children, which is the foundation for a child's knowledge, skills and behaviour, that utilize these for their growth. In a comparison of online teaching with face-to-face, it lacks human connection, absence of collaborative teaching, supervision, and the most glaring lack of opportunities for hands-on teaching. A student enrolled at school, who attends classes and devotes time can attain the appropriate level of mastery of a subject under a teacher's guidance.

Materials and Methods

To overcome this, we have introduced a concept of teaching by way of prepared videos. This enables teachers to prepare and show proper spotters, to encourage children to find out or identify it. During the online class, as the teacher is playing pre-recorded video, she observes children, and if they could not understand the subject she can ‘pause’ the video and explain in the way they could understand.

The activities that we usually do at school can be done online in an understandable way at the primary education level. Although we understand direct schooling (formal education) will not have an alternative, because of Covid-19, it is essential to keep children engaged in learning. Since children are at home, teaching online is not that easy, making them concentrate without distraction.

Challenges and Results

We encountered some of the challenges. Here is the list:

- All parents don't have a smartphone
- Illiterate parents have difficulty in opening the video and online links
- Technical glitch due to low network signals
- Teachers are reluctant to include technology into teaching.
- Small assignments have not done by children due to the problems they faced (as mentioned earlier)

The Strength of the school children was 30 in numbers. This year there were no new admissions and around 7% dropouts. Among children's attendance, 76% were regular for online classes, whereas overall attendees were 93%.

Conclusion

Online education, with the help of virtual classes, has a significant impact on children’s studies. Virtual classes had a positive effect since these were also available offline. And hence could be used by parents at their convenient times. Electronic gadgets have their health hazard implications and could compromise children’s health. However, due to Covid -19 pandemic, it was necessary to have classes.

Since the number of children was less, it may not have represented all aspects of the challenges faced during online teaching, and a more extensive study is needed to draw a definite conclusion.

Innovative Scientific Experiments in Online Teaching

Priyanka Shrivastava, Kendriya Vidyalaya CRPF, Durgapur

Introduction

The year 2020 was known for its bad experiences, but the good thing is that it was a milestone year in India's educational history. Every stakeholder of the education system adapted itself for the digital teaching-learning process. There were many problems like availability of computers, smartphones, internet connectivity and digital dealings initially but we altogether overcame all these hurdles. I also tried my level best to make my online classes interesting for the students. I used many digital platforms like WhatsApp, YouTube-live streaming, Zoom, Google- Classroom and Google- Meet for online teaching. I adapted many innovative practices like conduction of experiments with the material available at home, virtual garden tour (students showed their own garden telling plants name), spice activity (students showed different types of spices with their Hindi name, English name and the part of the plant they belong to), video and images display through sharing option, use of O-Lab platform to conduct Class 9 to Class 12 level practical simulations. I hope that we will continue using all these technologies in the coming future for the betterment of the education system in India.

Teaching During Pandemic

2020 was a very critical year for all of us in all walks of life. We were not prepared for that situation. All of a sudden, everything stopped. Everybody was confused about whether we would be alive at the end of the year or not. What will we face this year? How will things go on? We were in total confusion with lots of questions in our minds. 2020 was a bittersweet year when the world stood still but it was also a year of learning, a year of adaptation, a year of challenges and a year of change. For the world, this transformation was the most drastic and dramatic. This year totally revolutionized the education system in India which I can’t imagine one year ago. Technology and digital literacy that were previously difficult to address became the backbone of teaching. The year made online and blended learning even more relevant than before. The danger of spreading misinformation through misuse of technology was a big source of trouble with us too.

In the year 2020, we taught using traditional ways and were not acquainted with digital teaching methods. Heads of schools with the teams of teachers, students, and the help of all stakeholders started education on a digital platform. Digital accessibility was the primary obstacle, such as lack of - laptops, desktops, smartphones, internet connectivity and digital knowledge. Firstly we started with the most straightforward mode: WhatsApp. We prepared class-wise WhatsApp groups of students and included the Principal and Vice-Principal for vigilance purposes. We started providing chapter wise study material (e-content). I also began sharing links to some informative videos and other e-contents. We also tried the YouTube online streaming mode. After that, we switched to Zoom, but this had some safety issues. Kendriya Vidyalaya Sangathan, in

collaboration with Google then facilitated a better and safer online platform of learning. We used Google Classroom and Google Meet with the institutional email IDs. This facility was then extended to all the stakeholders like administration, teachers, and students. Initially, we faced issues but soon became the experts following advice of the Principal, Vice Principal, other teachers and students.

Science Teaching and Experiments

Teaching science is challenging, and teaching in online mode is a daunting task. I adopted many innovative initiatives in scientific pedagogy to make my online classes interesting which are described here.

Experiments at Home

I conducted many experiments on many science topics with the material available at home. For example, based on acid, bases, neutralisation reactions, indicators of acid and bases was conducted in online mode. Later I encouraged students to repeat the same and to make videos of it. These videos were collected to create a data bank for further use. Students were happy to do it and shared many videos [1].

Virtual Garden Tour

I also conducted a garden tour activity with my students where every student could show their garden in virtual mode telling the names of plants for identification purposes. In this way, they recognised plants, learned their names, and observed some unusual plants like ginger, turmeric, and cardamom. Every student showed their garden and told us the names of winter flower plants like rose, petunia, salvia, marigold, gladiolus, and asters. Some also showed vegetable plants like potato, tomato, brinjal, chilly, capsicum, onion, garlic, cabbage, and cauliflower. We also discussed which part of the plant becomes a vegetable. Students were very enthusiastic while doing this activity, and the learning outcome was also very high.

Recognition of Spice Activity

I designed a spice activity as a subject enrichment activity. I instructed students to show different types of spices present at their home through screen sharing mode. They gave names of spices in Hindi and English and provided the name of the part of the plant. For example, cinnamon was shown by one of the students, then I asked for the Hindi name (*Dalchini*) as well as English name (already mentioned), and I told the students that it is the bark of the plant. Students actively participated in this activity and exhibited their language and scientific skills.

Video Demonstration by Screen Sharing

It was a bit difficult for me to show some Science videos during regular classes because of infrastructure limitations. But online classes gave me this unique opportunity. I shared several videos. Here is the list of topics: salt formation from seawater, hydroponic, some lab experiments

which are not possible to conduct at home - like burning of magnesium (as the material is not available at home), simulations of working of different human organ systems and simulations of other natural phenomena. Sometimes students were keenly interested in sharing the screen. I used a virtual reality app arloopa for making some of the e-content.

Conduction of Biology Practicals on Olab Portal

O Lab is an online lab developed by C-DAC in collaboration with Amrita Vidyalayam Bangalore [3]. The O Lab is based on the idea that lab experiments can be taught using the Internet, more efficiently and less expensively. The labs can also be made available to students with no access to physical labs or where equipment is not available owing to being scarce or costly. I used this platform to conduct class 12 Biology experiments. Students interestingly conducted all the experiments there through simulations.

I feel proud to say that the central government, Ministry of Education, State Government education department, millions of students, teachers, principals, and parents across India embraced this change. As we welcome 2021, let's ensure that the learning from 2020 is not forgotten and is well incorporated in our plans and new education policies. For 2021, we will focus on infusing our digital platforms to support today's education system in preparing young minds with tomorrow's skills.

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Developing an Online Interactive Environment for Science Teaching and Learning

Asma Mubeen B. Mulla, Christ Academy School and Jr. College, Navi Mumbai

Introduction

Combining the online classroom interaction tool mode with the traditional computer-assisted instruction, the teacher needs to prepare more before-class, show more professional skill in-class, and interact more with students after class. For students, the teacher creates a new learning environment which requires more self-study and involvement to finish the task and interact with peers. Furthermore, the role of the teacher and students are reversed under this new learning mode. The teacher is not the only one who decides the teaching content; students also are. Teaching an online class requires much more time than a face to face class. When considering teaching online, many faculty members report a daunting time commitment.

Tools for Interaction in the Online Mode

Amid Covid-19 pandemic due to lockdown and various social distancing norms and guidelines, teachers all over India were forced to adapt to a new system of the teaching-learning process. We preferred using the Zoom app for online teaching because of the vast features like screen share, annotation, whiteboard, chat etc. Initially, it was a difficult task as it was a new approach for me. With a single training session, we teachers were ready to transform from classroom teaching to online teaching. There are some online tools that educators and students can use to teach and learn virtually.

- *PowerPoint* – PowerPoint has been a significant tool for preparing the study material for online teaching. The PowerPoint presentations are slides containing text, images and other media, such as audio and video clips. Graphs and diagrams can be presented easily with the teacher's audio explanation maintaining interaction with the students.
- *Screen Share* – The PowerPoint presentation or videos can be shared on screen very easily using Zoom app or other apps like Google Meet, Microsoft teams etc.
- *Annotation* – Annotations on the screen can help a teacher in writing the chemical equations, formulae, solving problems, highlighting the main points of the presentation etc.
- *Chat* – Chat is used for real-time, synchronous conversation in written form.
- Google form – Google form can be used to administer tests and quizzes, surveys, etc.

- Google Classroom – Assignments and home-works can be given to the students and they can submit them here.
- WhatsApp – Groups created have been a great help for the teachers to give announcements and information with the students.

These tools offer functionality which allows instructors to deliver course content, enable communications, and conduct evaluations.

Online distance learning meets the needs of many students who were locked in their homes during the pandemic. The minimum requirement for students to participate in an online course is access to a computer, the Internet, and the motivation to succeed in a non-traditional classroom. Online teaching provides an excellent course delivery method unbound by time or location, allowing for accessibility to instruction anytime from anywhere.

The online classroom requires new teaching strategies and instructional techniques. The person leading a successful online class must be a proponent of facilitative learning and have confidence in the system to make it work. Online facilitators should be open, concerned, flexible, and sincere. An online instructor must be able to compensate for the lack of physical presence in the virtual classroom by creating a supportive environment where all students feel comfortable participating and especially where students know that their instructor is accessible.

An online instructor should be willing to give individual attention to students who may need extra help by organizing doubt solving sessions. *Seven Principles of Good Teaching* according to Chickering and Gamson (1987) are outlined here:

- *Principle 1*: Encourage student-faculty contact through private messages, students and faculty can communicate. Among other things, this allows instructors to be proactive by following up on students who do not participate in chats, discussions, etc. Students and faculty can also communicate through the discussion forums.
- *Principle 2*: Encourage student cooperation that allows for student-faculty contact can also be used for student-to-student contact. Assignments can be created to take advantage of this. Furthermore, discussion forums can help foster group work and collaboration among students.
- *Principle 3*: Encourage active learning. Instructors can take advantage of the rich interactivity on the Web by designing assignments around appropriate Websites. When

students come to these sites, they make choices, and they learn from their choices. Active learning also takes place when students work cooperatively.

- *Principle 4*: Give prompt feedback; students can see the results of their tests and view solutions to graded assignments immediately after submission. Instructors can and should promptly respond to student questions.
- *Principle 5*: Emphasize time on task, for example, give students something specific to respond to in each module via the discussions. Build in a reward system of points for each post and reply to the discussion forums. In other words, make posting and responding mandatory.
- *Principle 6*: Communicate high expectations. In your syllabus, you should include course goals and performance objectives. You might include model assignment submissions that can serve as examples for students to follow. The bottom line is that you must be explicit and clear in communicating your expectations to students.
- Principle 7: Respect diverse talents and ways of learning. Create assignments that offer students options. Giving students choices in their learning experience increases satisfaction and retention. Consider giving students options as to what format to submit assignments or projects. For example, they might design a Webpage, write an essay, or develop a PowerPoint presentation. There is no reason why all students should submit the exact same homework or participate in one discussion topic.

The convenience and flexibility of the online learning environment allow learners to develop new skills and further their education, regardless of where they live. However, for all of its benefits, online learning can sometimes feel isolating for students and faculty. The question is: how do you build a sense of community in your online courses? One approach involves cultivating more interaction—between you and your students and among the students themselves. Here are five practical tips for increasing the human connection in your online classrooms.

I feel proud that we teachers have tried to help the students in all possible ways and will continue to. A good teacher is like a candle- it will consume itself to light the way for others.

Challenges and Solutions in Teaching and Learning Science Online

Daison Jacob, Kendriya Vidyalaya Golaghat, Assam

Introduction

Major challenges in online Science teaching and learning are concerned with elements of Science learning like hands-on activities and experiments. We can ensure active learner participation through real-time demonstrations, recorded videos and simulations that can be used in bringing the expected learning outcomes. We can assess the learning outcome and plan for either extended activities or remedial classes, thus bringing the best out of each student. A short survey conducted among my students suggested that online classes can never be a replacement for lab work. So what needs to be done is, resuming the direct activities in lab or class and supplementing these lessons with the online possibilities for expanding the horizons of Science learning and raising the standard to a global level using the online resources available from many countries.

Science Learning is of immense importance for a country as Science and Technology have become a steering wheel for a Nation's progress. Therefore, the Science Teachers have a challenging time as they take online classes expecting the desired output. The Science Learning must include processes that take the learner by exploring, asking, investigating, experimenting, and progressively applying them. It demands demonstration, guided discussion and real-time evaluation of the learning from a teacher. Teachers must ensure the development of cognitive, affective and psychomotor domains. From planning to the assessment, as a teacher who had never handled classes online, I faced challenges too during this lockdown period.

Doing Activities Online

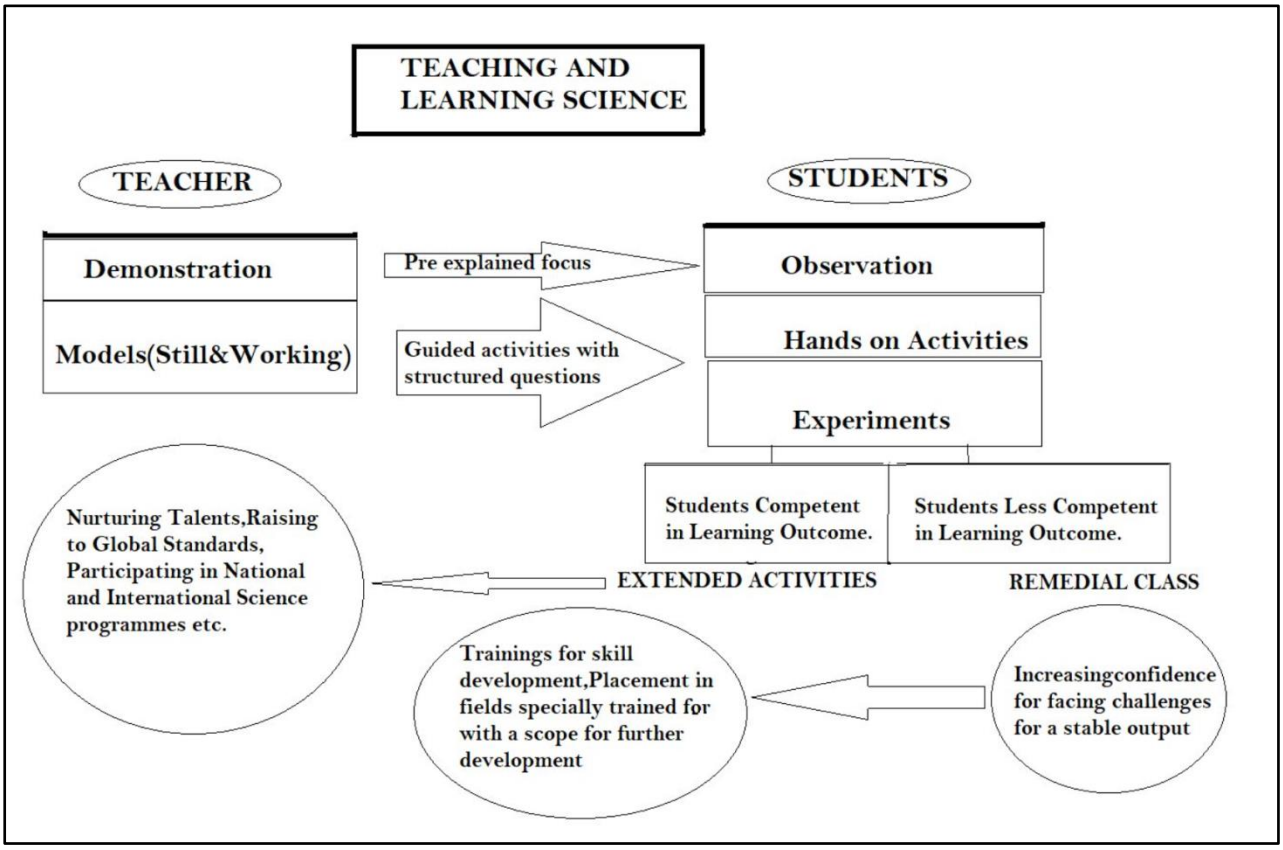
Activities are the prominent veins of Science Learning, without which Science learning is impossible. One can categorise these activities under the following headings. Here I describe how I handled these with students for active participation during my online class.

Demonstration: Online demonstration has an advantage as every student can see it clearly. Rather than doing on time demonstration, it is better to present the prerecorded video of the demonstration. This will ensure the expected result is obtained as required. Sharing the link of such videos will help students to review the activities. Osmosis, diffusion, transpiration, parts of a flower, parts of an electric torch, movement of different joints, natural fibres, etc. are a few examples I had done successfully via recordings [1] or as live [2].

While teaching Pinhole Camera, I used the model and focused the lens of my mobile phone to the screen of the Pinhole camera and the students were able to see the inverted image of our school

using the pinhole camera in real-time. They also observed the image of the sun using the same camera. While explaining the structure and function of flowers, I was outside showing students various stages of this reproductive structure in real-time from a single plant, i.e. from bud to fruit formation.

Diagram 1: Science Learning For Developing Oneself And The Nation



Hands-on Activities: Following the demonstration by the teacher, students may be asked to perform the same. I asked my students to dissect and display five different types of flowers, transpiration. One can also ask students to work on a new activity for further development of the concept where they can modify the activity by replacing the material with another suitable item. For example, in the experiment of the time period of a pendulum, the students can make a pendant with the stone, ball, or any other materials instead of a bob. The teacher can ask a few students to present the activity. Blowing the paper ball at the mouth of a bottle, blowing the air over the paper strip, producing sound using sheets of paper, etc. are a few examples which my students enjoyed doing. While teaching the shadow formation I used a mobile flashlight for explaining and the students also presented shadow formation in sunlight using video mode.

Using models: We use models in physical classrooms. Such models can be used in online mode, but there are many 3-D Animated versions of videos where students get a clearer idea of what is being discussed. For example, I cannot forget how my students enjoyed watching the video ‘Travel

Deep Inside a leaf by the California Academy of Science' [3]. Regarding working models, the teacher can use a video to explain the working of the model, and the students can then be asked to find out how they can make the model.

Doing Experiments: I have conducted a brief survey with my students, and on the point about doing experiments, all students agree that online classes can never be equal to face-to-face classes.

I used KClass Science Channel videos [4] and those available on the Diksha portal during the online classes. As these clearly show the processes and results, students got more or less the same visual effect as that would be from a lab

As a teacher who worked in various schools, I want to emphasize the lack of enough lab facilities and equipment in many schools. I would like to suggest setting up public laboratories nationwide with all the facilities as the sub wings of major research institutes, with a booking system for using the lab for various experiments. Priorities should be given for less privileged students regarding lab facilities in their school.

Challenges Of Online Science Teaching

Although I have tried to conduct activities online, there are some difficulties which I had to face, which are described below.

1. *Increased screen time posed health issues*: As a result of daily online classes, not less than four classes per day, I found it a challenging task in checking notebooks and assignments. I had to compromise with it. I tried to use textbooks more in my teaching, where students would get time to take their eyes off the screen. I gave some writing, drawing and explaining activities during the class.
2. *Ensuring the participation of all learners*: Most of the classes have 40-50 students. Students have to turn off their audios and videos for a better signal during the classes. This is misused by a number of learners where they either do not respond or simply answers the question while doing some other activities. The solution is to have a teacher controlled audio-video system for every student or the class as a whole. As such a system is not available I tried to take the help of parents, but that too was not completely helpful.

   While some students faced the issues due to a poor network, some other students exploited the chance of not meeting the teacher face to face and ignored the online classes. I had to travel faraway places to reach out to those students to find out the real reasons and motivate them for participating in online classes. For such students, I have also prepared self-learning support materials [5] with video links, chapter review, chapter notes and extra exercises along with Diksha links for each class (all links on a single pdf).
3. *Catering to the needs of special students*: I have two special students, one with autism and ADHD and another with very low IQ and speech disability. Before online classes started, I

used to take after-school special classes for one of them, as the parent had agreed to sit with me while teaching. For the other student, I could not do much other than encouraging her. However, once online classes started, these students were not at all helped even though they were attending classes.

4. *Encouraging competent students*: As the online classes have introduced a time constraint, it was hard to encourage gifted students to learn more. I created a special class and WhatsApp group for such students. Online gathering for learning extended topics once in a week or as per convenience helped advance the scientific attitude among students. I have been taking such a class outside school hours once a week for a heterogeneous group of students. I was inspired to start that class as a result of attending Vigyan Pratibha Discussions on various learning units, organised by Homi Bhabha Centre for Science Education.

Conclusion

Online science class has many benefits compared to usual classroom lessons like better visibility, more convenience, and fast accessibility of materials and resources. Yet it cannot replace lab activity even with any latest technological advancement. So we need to take up real-time physical classroom lessons that can be supplemented with online coordination and extended activities necessary for the maximum desired output.

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Nurturing the Scientific Temper through Online Classes

Devaki Ramanathan, Lalitha Dhareshwar, Madhu Pahwa, Manashi Chakraborty, Rama Prasad, Smita Kekatpure, Srirupa Mukherjee, Sukhvinder Sandhu, Suparna Kamath, Tripta Tewari, and Vijayalakshmi Tilak,
Indian Women Scientists' Association (IWSA), Navi Mumbai.

Introduction

This paper illustrates the teaching methodology of science lessons to school students through the virtual platform, as a means to develop their scientific temper. Hands-on experiments using the day to day materials and household items were selected. The teacher and the students conducted the carefully planned experiments, together, from their locations. We taught systematic observation along with record keeping and logical deduction. They were also instructed to write a short dissertation on the experiments, thus enriching their scientific vocabulary and writing skills. We taught mathematics with puzzles and games, which made these students competent and confident. The paper discusses how the students' scientific temper could be enhanced by the innovative methods adopted by the teacher during online teaching.

Scientific temper is an individual's attitude for logical and rational thinking. The inquiry-based learning process involves the important steps of systematic and keen observation, thinking based on evidence, reasoning, and logical deduction. This process helps to inculcate a scientific temper in students at the school level. As the students grow up, the scientific temper can transform every aspect of their life and endeavour for the better. The growth and development of a society are thus linked not only to the level of education but also to the rational and scientific temper of its people.

The pandemic has given a paradigm shift in the learning process from primary school to university education. Online teaching has challenges like lack of attention, slipping out of online class and lack of participation. The only way to surmount this is to make the class as interesting and participative as possible. In particular, science has to be taught through several experiments which can be conducted by students themselves at home.

IWSA has been running a Science Nurture program, since the last eight years, for school children in the 7th and 8th grade from under a privileged section of society. About 15 children are taught science, Mathematics, English and computer skills, every day for 2-3 hours, four days a week. Science is taught through hands-on experiments. In the English class, we try to establish conversation and improve their vocabulary and communication skills. In the computer class, they are taught to use MS-Office. They are also taught to research a topic from their book and make a

PowerPoint presentation to the class. This program has helped realise IWSA's mandate of taking science to the masses and inculcating a scientific temper in tomorrow's citizens.

Methodology for teaching during the COVID situation

- Google Meet platform for online classes.
- To describe the lesson of the next day created a WhatsApp group of students.
- Students instructed to collect and keep ready the components/ingredients needed for experiments to be conducted the next day.
- Many of our students cannot afford mobile data; hence IWSA pays for their phones.
- During the class, the teacher asks the students certain questions about the topic and asks them to demonstrate experiments in front of their camera.
- The teacher does the same experiment after everyone has completed. She can give reasons if students are not successful.
- The classroom is made exciting and participative using the Google App to show 3 D models.
- In between, few questions are posted on the chatbox, which the students have to answer. This keeps the students alert throughout the class.
- At the end of the class, the teacher can post some video links of YouTube videos relevant to the topic.
- For making simple projects and active participation in the classroom, the children are rewarded with data points in their mobiles.

Some of the experiments performed in the online science classes are given below.

Demonstration of osmosis and diffusion

The children learnt osmosis and diffusion using simple DIY experiments. We told them to fetch a glass of water and add a crystal of potassium permanganate into the water and observe diffusion. Then We told them to soak raisins overnight in two jars, one of them containing plain water and the other sugar solution. Students noted the results seen the next day and took pictures and posted them on the WhatsApp group (Fig 1).

Fig 1

The teachers demonstrated how soaking an egg in vinegar for two days makes it lose its shell and become translucent. When soaked in plain water, this translucent egg swells up since its membrane is permeable to water and shrinks in sugar solution as it tends to lose water. The teachers easily explained hypertonic, hypotonic solutions concepts with the above examples.

Demonstration on properties of light

In Fig 2 (a) and (b), show that objects on heating emit light, confirming that the light is also a form of energy; (c) shows straight-line propagation of a beam of light from a laser pointer through turbid water; (d) shows a demonstration of bending of light in a stream of water, explaining the principle of total internal reflection which is the basis of light propagation through optical fibres; (e) and (f)- show demonstration of the composition of white light using Newton's wheel, (g) and (h)- show examples of Optical illusion.

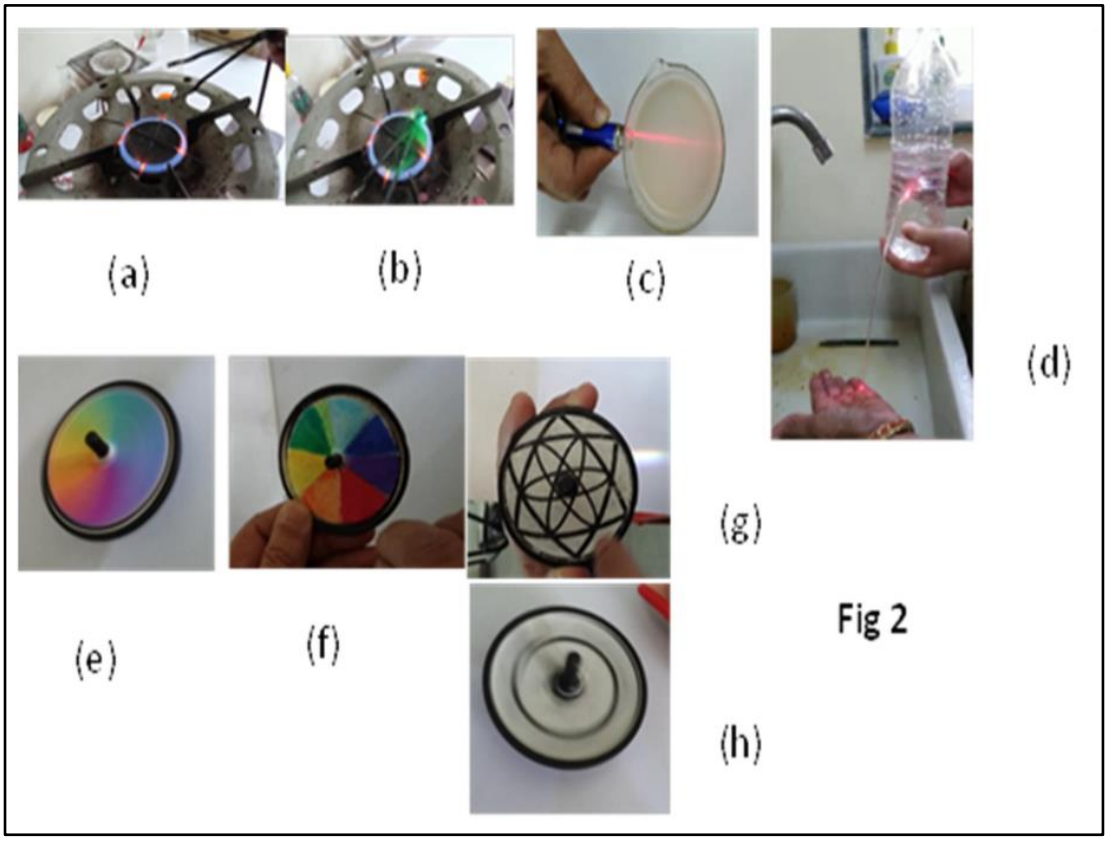

Fig 2

Metals and non-metals:

Students compared simple metallic and non-metallic objects. They compared articles made of aluminium, silver, copper, iron and gold from their house for colour, strength, etc. The difference between iron and steel led to the idea of alloys - brass, bronze was introduced and discussed. Propagation of sound through different metal bells and plates was examined by hearing the sounds. Wires, coins and vessels of copper were shown to demonstrate ductility and malleability. Thermometers were examined to observe liquid metal like mercury. The teachers showed the difference in the properties of mercury and gallium with YouTube videos.

Acids and Bases:

Teachers taught acids and bases by making indicator solutions and papers using turmeric solution, the juice from hibiscus flowers and purple cabbage. These indicators show a discernible colour change in lemon juice and soap solution. These strategies have helped to stimulate keen observation, curiosity and imagination, enhancing scientific temper and at the same time children are kept entertained and alert.

Use of Google apps to show 3D models:

The teachers told the children to check out the 3D models of bacteria, animal cell and plant cell using Google app (Fig 3).

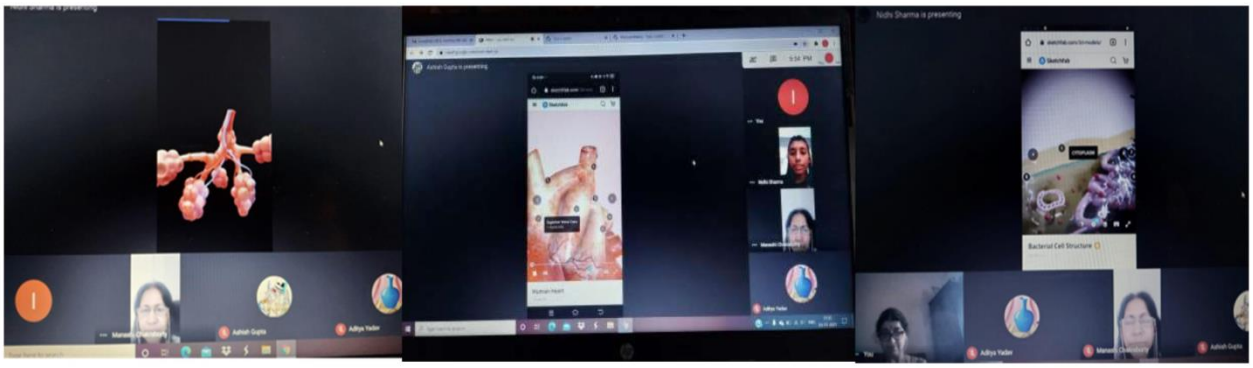

Fig 3

The excited children worked with one another and presented these 3D models on their mobiles to the teacher. It was a pleasant experience to be taught by the children rather than the other way round. The alertness and involvement in the subject were so much that students who normally are not very responsive in online classes (irrespective of the topic) were very eager to present all these 3D models! The 3D models were systematically labelled, and the names popped up as the presenter clicked on the label numbers. So the children learnt the location and structure of each organelle in the cell. The high quality of visuals in these models has had a significant impact on their minds. Instead of the teacher being eager to teach the children and complete the stipulated portion, the children were keen to continue the class well beyond the slated time!

Using Google's virtual reality tour:

The children were shown a virtual tour inside the respiratory system with travelling through the bronchioles, inside the lungs, gliding over alveoli and seeing the fine capillaries surrounding and a comparison of a healthy lung with a smoker's lung. These tours have a narrative for certain sections, which worked well for English medium students. But we preferred to keep the audio off and give a personalized tour with our commentary whilst showing the 360-degree angles of the various parts of the respiratory system and the heart! Mathematics is also taught in a fun way focusing on the underlying concepts to overcome Mathematics-Phobia.

Conclusion

The above teaching examples show how an innovative teacher can conduct all the science classes in the online mode and stir up the observation and logical deduction in the students, so important to inducing a scientific temper.

Learning Science Experiments in Online Mode

Mercy Varghese, K J Somaiya Comprehensive College of Education, Mumbai

Introduction

Learning never stopped even during adverse situations like pandemic COVID-19. Online learning never replicates real school interactions but still provides a great opportunity to avail high-quality education with the help of internet connectivity. But the practical work, which is an essential element of science teaching, presents a particular challenge in remote learning. However, there are many ways to ensure that this part of the science curriculum isn't neglected when teaching remotely. Many websites offer a range of useful on-screen experiments and interactive simulations. Besides, YouTube has a wealth of video demonstrations that students could watch. Teachers can be creative and use different methods like games and breakout room to develop students investigative and research skills while learning remotely.

The severe impact of COVID-19 has shaken the world to its core. As a part of India's nationwide lockdown, the government has closed all educational institutions. Consequently, learners ranging from school going children to postgraduate students are affected. Digital education appears to be a viable solution to fill in the void for classroom education. Digital learning has many advantages in itself like digital learning has no physical boundaries. It has more learning engagement experience than in traditional ways. It is also cost-effective, and students get to learn in the confines of their comfort zone. However, digital learning is not without its limitations and challenges since face-to-face interaction is usually perceived as the best form of communication than the rather impersonalized nature of remote learning.

'Science without practical is like swimming without water'(SCORE, 2008). Practical work is an essential element of science teaching – and presents a particular challenge in the context of remote learning. However, there are many ways to ensure that this part of the science curriculum isn't neglected when teaching remotely. Teachers might be dismayed that their students can't carry out the practical work planned, but students can still develop their investigative and research skills while learning remotely.

"Professors must get creative and use a combination of what is available," including online videos and free or commercially available online labs, says Mildred Pointer, a physiologist at Howard University. No single tool meets all their needs, Pointer says. In the difficult phase of this pandemic, the teacher's goal will be to deliver clear instructions to your students and create labs they can perform without a teacher present while reducing technical glitches.

Methods to teach Science practical remotely

To inculcate scientific knowledge and scientific outlook in our students, teachers can use different methods to emphasise concepts and experiments. A few resources are listed here.

1. **Virtual Lab:** Virtual laboratory is a computer-based activity where students interact with an experimental apparatus or other activity via a computer interface.
2. **Simulation:** You can't bring a nuclear reactor into the home, but you can simulate it; you wouldn't want students working with disease sample at home, but they can use simulation. Thus, indirectly the students can learn by doing. A simulation is an approximate imitation of the operation of a process or system that represents its operation over time. Or we can define simulation as a model of a set of problems or events that can be used to teach someone how to do something or the process of making such a model.
3. **Video Demonstrations**: Demonstration is the act of showing someone how to do something, or how something works. Teachers can make videos or use many online videos to understand the concept behind every practical. Some teachers have made interesting videos demonstrating various experiments. For, e.g. Professor Prakash Surve has demonstrated few biology experiments for std XII wherein students can efficiently perform the same using the material available at home, thus providing hands-on experiences.
4. **Online Laboratory Class:** Students in an online laboratory class can be divided into groups of two to use their actual lab experience and understanding of the techniques to propose new experiments. By working in pairs, each student's voice is heard, and ideas can be explored and discussed. In zoom, teachers can use a breakout room to divide the students into groups and work together.
5. **Games:** Faculty members can also develop new and creative approaches to teaching. For example, to teach experiments related to genetics in std XI, a game of genetics Jeopardy can be created either by professors or students, where students can play with their professor or other students online.

A few examples of different apps and links for the science practical are listed here.

1. **iOLab**: iOLab is a revolutionary new hardware and software solution for physics lab. It combines all the measurement devices and components needed for hundreds of physics labs in a single device and links them to a software solution to gather data and record results. It has built-in sensors which measure force, acceleration, velocity, displacement, magnetic field, rotation, light, sound, temperature, pressure, and voltages down to a few μV. Expansion connectors provide access to over a dozen user controllable digital and analogue inputs and outputs. Free software controls the device, acquires and displays data in real-time, and provides a suite of analysis and data manipulation features.

2. **LabInApp**: This virtual Lab uses computer graphics technology to simulate the science experiments from NCERT laboratory manual. The science experiments cover all the aspects, including performing the experiment as per procedure, taking readings, observations, tables, graphs, and conclusions. LabInApp is an app on google play store for Chemistry, Physics, Biology, and 6 to 10 science.
3. **OLabs**: The OLabs is Developed by Amrita Vishwa Vidyapeetham & CDAC Mumbai. It is initiated and funded by MeitY (Ministry of Electronics & Information Technology), Government of India. The content is aligned to NCERT/CBSE and State Board Syllabus for Physics, Chemistry, Biology Labs from Class 9 to Class 12 and English and Maths lessons for Class 9 and 10.
4. **Dhananjay Parker**: Dhananjay Parker for simulated lessons of XI and XII (Physics)
5. **Virtual Labs at Amrita Vishwa Vidyapeetham**: This project is an initiative of the Ministry of Human Resource Department under the National Mission on Education through ICT.

In the long run, successfully adopting innovative ways to facilitate interactive learning will be invaluable for science education.

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Class Room to Zoom

Payel Bhattacharya, Nursery teacher IWSA

Student: “Good morning teacher”

Teacher: “Good morning my dear children, join your palms, close your eyes, now say the prayer.”

Suddenly my mobile alarm is ringing, and I see it’s 7.30 am. “Oh it’s too late. How could I manage everything, my reporting time at school is 8.45am, oh God help me!!”

Then I remember there is no contact school from the last eight months.

No one to hug me in the morning or to say, good morning teacher! No one comes to school. Only I need to send one zoom link before class and parents attend the class, and I will show some videos and activity videos that’s all.

Some children are not attending the online classes also, because they want only videos.

Is it suitable for a child’s development? Are their fine motor and gross motor function improving properly? Is their cognitive development occurring correctly?

No, the classroom is a very effective place for everyone, not only for children but also for teachers. This is where we interact with each other. We enjoy all the moments at our school.

In an online class, we make a virtual background for classroom effect, but the children who have no idea about the classroom who have never attended school will understand this background?

From the first day of school, we make the students feel that the teacher is your second mother, but they don’t feel the relationship between student and teacher in this online class.

So, we pray that in 2021 everything will normalize as early as possible.

Geo Science club: The Science Hub!

Pravin Shinde, Co-ordinator - Geo-Science Club,

Vigyan Prasar Network of Science Clubs

Introduction

The geo-Science club is a science club, part of Vigyan Prasar Network of Science Clubs, through which I held various activities for the students of my block (taluka). Since June 2017, I am striving to develop a science environment through which students can learn by doing stuff. This club is focused on 21st-century skills like critical thinking, collaboration, creativity, and communication. As part of the club, I have developed different activities like a lab in hand, talk with Gyan, a search for talent, reading Katta, birthday with science, Sunday trek, solar lamp making workshop, digital repository, etc. With these activities, I want the holistic development of students with fulfilled learning. The club also works with parents.

Science is not just a subject; it is a basis for human life. Without accepting Science, no one could live better, that's why I try that Science will come to our daily life and not just remain books. So I used the slogan "LETS LIVE THE SCIENCE" because nowadays there is a requirement of society to learn Science with a new way of the new world, i.e. online mode.

Study from home during Covid-19

Due to the Corona virus pandemic, all are stuck in lockdown from the end of March; all schools have closed no class and no teaching and no study. So I decided to start study from home, and I began developing science experiments videos. Through experiments, one can learn and understand easily. I made videos of experiments with readily available material to do experiments. These videos were sent to parents mobile. Students conducted experiments at their respective homes based on these videos and sent their recordings to me. This initiative inspired our district authorities to start school from home.

Science Quiz by Google Map

Google map is an online tool by which we can revise and assess what we learnt. Instead of assessment, I used this tool for learning and getting new knowledge about Science. I focused on animals, plants, birds, the solar system and more exciting things about them. About these topics, I made ten quizzes having ten questions for each case. I shared these google forms everywhere with the help of Social Media. I am so happy because I got more than 5000 replies to these forms. I got many phone calls and messages for the appreciation of this activity. Through google form, I provide a new way to learn and acquire further information.

General Knowledge Through Audio Books

General knowledge is a unique subject in which different streams are included. Through this activity, I tried to improve my understanding of people about science. Generally, we see in society; people have not enough information about daily life and its various aspects. So I made available an audio series that contains information that is very useful in the daily routine.

Explore Universe

Explore the universe is an activity which is held on google form by online mode. The universe is vast and has enormous wings of knowledge. Most of the people, students and teachers are not aware of this subject. But this subject is exciting and has ample scope in the future for the students' lives to improve the interest of students and teachers. I started this activity . with the help of audio-books and google forms I could publish and share a lot of new information to all.

My Science Experiments

During the lockdown, students have enough free time to do and learn new things. To improve 21st Century skills, I held a video making competition for the 6th to 8th-grade students. In this students took part vigorously. They tried to present themselves and during this process, learned many techniques about making a video, recording voice, sending an email etc. I made a smart pdf of Science experiments that is very useful to all students and teachers.

Audio Book of Indian Scientist

Like the general knowledge series mentioned above, I started a new audio-video series on Indian Scientists. I streamed these on my YouTube channel named ‘Pravin Shinde’s Hub’. I have published more than 15 videos here. Through these videos, students, teachers and also parents got information about scientists and their work. Through this, I want to do science popularization work. These audio-books are also helpful to blind students and people.

Glimpses of the work


GEO-SCIENCE CLUB


GEO-SCIENCE CLUB

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Online Basic Botany Experiments: Microgreens Cultivation

Smita Kekatpure, Priya Jacob, Madhu Pahwa, Sukhvinder Sandhu

Indian Woman Scientist Association (IWSA), Navi Mumbai

Introduction

Microgreens are highly nutritious baby plants. Today when the whole world is facing a pandemic, growing your own vegetables at home is the need of the hour. At the same time online teaching & learning is also a must. During our interaction with the students in their online Science classes we were successful in teaching Basic Botany through microgreens cultivation to the students. Excellent results were obtained by the students & teachers while growing microgreens & the students learnt their Basic Botany concepts. In doing so, we could also teach them the importance of "Atmanirbhar Bharat" & that they are a part of it.

We at IWSA are actively involved in building scientific temper in children by means of various scientific activities, events, science experiments, audio visuals & field visits to our Learning Garden. Our Learning Garden which came into force on the environment day, June 5th, 2018 at IWSA HQ, Vashi serves as an open-air laboratory for students of various age groups & backgrounds. During the COVID-19 times we were successful in creating an online interactive environment for teaching & learning. Experiments were designed in such a way that all that is required for the experiments is available in their homes. Students from a nearby English medium high school are a part of our science nurture programme.

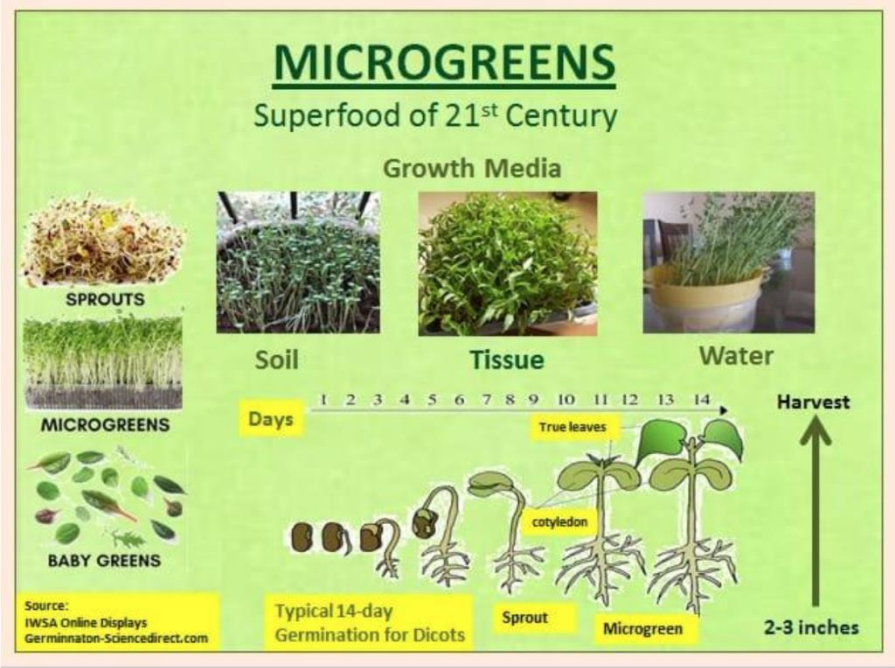
Microgreen cultivation & basic botany experiments were taught to these students by interacting with them online. Designing such engaging activities can be effective teaching tools. It helps to develop skills & concept learning.

About Microgreens

Microgreens are vegetable greens harvested just after the cotyledon leaves have developed. They are also called green baby plants, about 1 to 3 inches tall having basic requirements for cultivation at home. They are used as a nutrition supplement, a visual enhancement, and a flavour and texture enhancement. Microgreens can add sweetness and spiciness to foods. A wide variety of microgreens can be developed from different types of seeds.

Iwsa's Approach To Online Teaching Of Microgreen Cultivation & Basic Botany

- Cultivation of microgreens in 3 different mediums Soil, Water & Tissue paper for the comparative study was done.
- We used a handful of Seeds readily available at home during COVID-19 times like Fenugreek (Methi), Green gram (Moong), Moth bean (Matki), Chickpea (Chana) & Blackeyed Pea (Chavli). At various intervals, different seeds were soaked & the concept of imbibition & viability of seeds was observed.
- Seeds started sprouting - we taught the concept of germination. At this stage, we sowed them in 3 different mediums.
- A small layer of soil is needed to sow & to cover the planted seeds. It was watered & kept in sunlight. We made observations to study the radicle, the plumule & the cotyledons.
- As the microgreens started to grow, we taught geotropism's soil concept, phototropism & photosynthesis.
- Harvesting was done after they attained a height of 1 to 3 inches, the time when the leaves are just out of the cotyledons. At this stage, we taught the nutritional value of microgreens, experienced their taste & flavour.
- For microgreens cultivation on the water, a plastic basket with holes was taken. Soaked seeds with small sprouts were sprinkled. We kept this basket in a container having water in it.
- Care has to be taken that as the microgreens grow the root tips should not dip in the water. A gap has to be maintained throughout their growth.
- We changed the water in the container twice daily. Initially, for the first two days, the seeds in the basket were kept covered with a wet cloth, so that the seeds did not dry. They are not exposed to direct sunlight for the first two days. Rest of the botanical studies were done as with the soil.
- For microgreen cultivation on tissue paper, we took a trey and placed two layers of tissue paper.
- We sprinkled water on it to make it wet. Soaked seeds were sprinkled on this damp tissue paper. The trey was covered with another layer of tissue paper & care to expose it to direct sunlight. Water was sprinkled 3 to 4 times a day. After three days the trey was shifted towards sunlight & we also removed the cover. Harvesting was done after the length of the microgreens was about 2 to 3 inches. We made observations & studies at each step.



Observations & Results

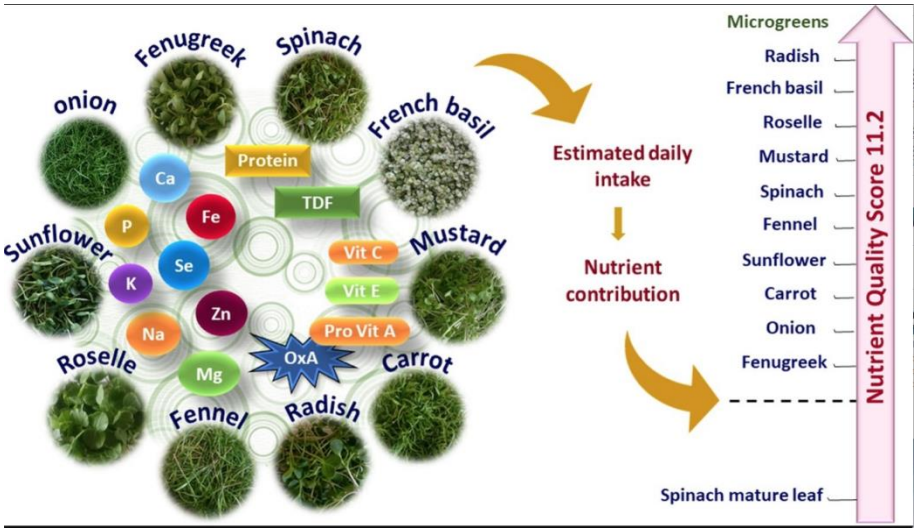
Comparative study of the growth of microgreens showed that water obtained quick results followed by soil & tissue paper. Seeds of fenugreek and chickpeas took longer as compared to the others. We found that weather conditions played a vital role in germination & growth. The children achieved excellent results in all the experiments.

Nutritional Profile of microgreens

Microgreens are packed with nutrients. Research comparing microgreens to more mature greens report that microgreens' nutrient levels can be up to nine times higher than those found in mature greens. Minerals and vitamins are an essential class of nutrients for human health. In minerals, both macroelements and microelements play crucial roles in our wellbeing.

Macro elements such as Mg, P, K, and Ca and microelements or trace elements such as Zn, Cu, Mn, and Fe are best obtained from dietary sources. A deficiency in one of these elements can cause acute and chronic diseases leading to death.

To bolster our immune system, we need our daily dose of vitamins. It is essential for proper biological process, healing and repair of cellular damage. Microgreens have been found to have an abundant concentration of these nutrients than their mature leaves. They are a rich source of phytonutrients, beta carotenoids, antioxidants, vitamin E, C and K and dietary fibre. The year-round fresh produce can help fill the gap of daily nutritional needs.



The figure above shows all microgreens when compared to mature spinach leaves as 2-3.5 times more nutrient dense. On NQS 11.2, radish is the most nutrient dense.

Source:https://www.sciencedirect.com/science/article/abs/pii/S0889157519317806

RECOMMENDED DIETARY ALLOWANCES FOR INDIANS

Group	Particulars	Body weight kg	Net energy Kcal/d	Protein g/d	Visible fat g/day	Calcium mg/d	Iron mg/d	Vitamin µg/kg		Thiamine mg/d	Riboflavin mg/d	Nicotinic acid mg/d	Pyridoxine mg/d	Ascorbic acid mg/d	Free folic acid µg/d	Vit B12 µg/d
								Retinol	β carotene							
Man	Sedentary work	60	2425	60	20	400	28	600	2400	1.2	1.4	16	2.0	40	100	1
	Moderate work		2875							1.4	1.6	18				
	Heavy work		3800							1.6	1.9	21				
Woman	Sedentary work	50	1875	50	20	400	30	600	2400	0.9	1.1	12	2.0	40	100	1
	Moderate work		2225							1.1	1.3	14				
	Heavy work		2925							1.2	1.5	16				
	Pregnant woman	50	+ 300	+15	30	1000	38	600	2400	+0.2	+0.2	+2	2.5	40	400	1
	Lactation															
	0-6 months	50	+550	+25	45	1000	30	950	3800	+0.3	+0.3	+4	2.5	80	150	1.5
	6-12 months		+400	+18						+0.2	+0.2	+3				
Infants	0-6 months	5.4	108/kg	2.05/kg		600		350	1200	55µg/kg	65µg/kg	710µg/kg	0.1	25	25	0.2
	6-12 months	8.6	98/kg	1.65/kg						50µg/kg	60µg/kg	650µg/kg	0.4			
Children	1-3 years	12.2	1240	22	25	400	12	400	1600	0.6	0.7	8	0.9	40	30	0.2-1.0
	4-6 years	19.0	1690	30			16	400		0.9	1.0	11			40	
	7-9 years	26.9	1950	41			26	600	2400	1.0	1.2	13	1.6		60	
Boys	10-12 years	35.4	2190	54	22	600	34	600	2400	1.1	1.3	15	1.6	40	70	0.2-1.0
Girls	10-12 years	31.6	1970	57			19			1.0	1.2	13				
Boys	13-15 years	47.8	2450	70	22	600	41	600	2400	1.2	1.5	16	2.0		100	0.2-1.0
Girls	13-15 years	46.7	2060	65			28			1.0	1.2	14				
Boys	16-18 years	57.1	2640	78	22	600	50	600	2400	1.3	1.6	17	2.0	40	100	0.2-1.0
Girls	16-18 years	49.9	2060	63			30			1.0	1.2	14				

Source: NIN, Hyderabad

Conclusion

Since we at IWSA are actively involved in building Scientific temper in students from various age groups & backgrounds, it was a challenge for us to teach them science experiments online. We were successful & can conclude that:

1. Learning basic botany experiments online & doing it at home was fun for them and got their concepts clear of the subject.
2. Along with basic botany, they learnt the art of Urban farming; Microgreens can be grown in your own house, on windowsills etc.
3. All the material needed was readily available in their homes
4. The whole family was involved in the growing of microgreens
5. Importance of microgreens in diet & its Nutritive value was also well understood &
6. incorporated in their diet.
7. This project-based learning helped students to make quick, nutritious meals. Children got
8. to familiarize themselves with healthy eating habits through active participation of family
9. members.
10. During the Lockdown period, such activity helped everybody to relax & destress
11. The children were made aware of the concept of *atmanirbhar Bharat* by cultivating their
12. own food with the limited resources available.

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(picture 1)

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Planning and Designing for Online Science Teaching

Swati S. Suryawanshi, Christ Academy, Navi Mumbai

To teach is to touch lives forever.

Knowledge and wisdom are two great things that come after initial education. An educated mind seeks knowledge and knowledge leads to wisdom.

Science is a body of knowledge.

Science is a method of inquiry, a way of investigation.

Science is an attitude towards life, a way of thinking.

As we are moving through rapid global technological changes, we have to acquire scientific literacy.

Scientific literacy means a clear understanding of the nature of Science and inter-relationship between Science, Technology and society. We should use the scientific ability to better understand the world around us as a result of scientific instruction.

Understanding how students learn can help us develop teaching methods that lead to improvements in students' learning. If our goal is to help our students, develop an understanding of science concepts and the scientific enterprise, we need to facilitate students' active involvement in their learning.

Considering the present situation of the pandemic of Corona, all over the world, made us rethink our teaching methods to attain scientific literacy through online teaching-learning .

The methods which are planned and designed in online teaching must consider

'Science' as Everything and everywhere

- The study of how and why things work
- Inquiring, questioning and investigating the world around us.
- Understanding our world.

We live in a Scientific World. Advanced teaching strategies will help students to discover and explore science in everyday life. Science teachers can plan and design methods in such a way that it will connect to the real world and make learning relevant to our student's interest.

As a Science teacher, we can plan the online teaching methods in such a meaningful and interesting manner to learn with innovative tools and develop their ideas and connect the scientific concept to the real world's benefits. Virtual teaching allows us to use Multimedia as an important tool in our teaching.

In offline teaching, various Science teachers used pair and share methods. For online teaching, the process can be modified and used as follows.

THINK, LINK and SHARE.

Let's discuss this method in detail, as we all experienced teaching online.

THINK: Science starts at home. As scientists say, Science starts at home, engaging our students to discover Science from day to day life. A teacher can give students tasks to discover how and why things work in their surroundings using a scientific view.

LINK: Students will co-relate the given task with surroundings and environment. Find its application, its importance and benefits for the society.

SHARE: Students will search related topics, make a model and show a quick demonstration by sharing the screen (as we are teaching online). This is the most useful method in online teaching which helps students: to develop interest, participation in activity, understand the concept and build confidence. It's an inquiry-based learning method. It provides a template, a pattern for lesson planning and guides teachers in a better way of teaching Science.

Utilizing technology in the classroom and integrating with the class is a great way to empower students to stay connected to this technological era. While teaching in the class, a teacher should design appropriate and relevant methods considering the following factors.

- Educational objectives
- Time and Material factors
- Teacher, Students and Environment

From the above factors, as we know, that time and environment have changed tremendously. So we have to reconsider the educational objectives by designing a flexible and student-centred approach in teaching our subject. Effective methods of teaching should involve: Preparation

- Presentation
- Generalization
- Application

So that students will apply new knowledge in new life situations. As a science teacher, who always believes learning becomes meaningful by doing. In the virtual lectures present situation, science subject can be taught using various activities, multimedia presentation, videos, and animation. These activities can be designed using the 5D Model, which can be used to make teaching-learning more interesting.

Online Tools: A Boon for Classroom Interaction

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With the technology advancing at every tick of the clock, the ways of communication have also evolved. The years went by, 2020 in specific, have had a significant impact on the way people connect and communicate. The covid-19 situation threatened the various pillars of society-economy, politics, administration, and media. Individuals, job opportunities, education, and all the other facets had to suffer a severe setback. In times of struggle, technology emerged as a saviour and helped people stand on their feet and facilitated the economy's survival. When the entire world was on hold, technology gave wings to essential sectors, including private sectors, banking, e-commerce, etc. Modern technology has also been spinal support in one of the crucial areas, that is Education.

Education is the founding stone of any civilization and culture. An educated person can observe the world rationally and cogently. A pause in education can cause considerable loss to the growth and development of a nation. During the pandemic, the education sector was shuddering for the initial few months because of the complete lockdown in schools and colleges. Realizing that this could lead to a substantial delay in the growth of millions of learners globally, educational institutes undertook the responsibility of imparting online education. Initially, the veteran teachers, who used traditional chalkboards for teaching, faced several difficulties in understanding the new technology and utilizing it for their teaching purpose.

Teaching is an esteemed profession which requires great dedication and perseverance. The teachers play an important role in moulding the habits, traits and characters of learners. The entire teaching process rests on how the teachers develop a healthy relationship with their students. Teacher Student rapport is the essence of the teaching-learning process. A teacher needs to create a comfortable environment where a student can come up for discussion and debate. It is quite evident that for building such a surrounding, interaction becomes indispensable. Interaction enhances the chances of learning. More the students get the opportunity to participate in discussions; more is the probability of their progress. Classroom interaction has always been at the core of the teaching-learning process. Classroom communication becomes easier when the teacher and the student share the same physical environment. But, rapport building seems to be a challenging area for the teachers when it comes to virtual space. Engaging students and motivating them to participate in the learning process is quite demanding on virtual platforms. Despite all these adversities during the pandemic, teachers never let any of these become a hindrance in their teaching. Instead they came up with innovative ideas to use the virtual space for interacting with students.

The online platform like Google Meet, Zoom, Microsoft Teams, Skype and many more became important tools in providing a virtual classroom environment. There are multiple tools that

teachers can utilize for imparting education online. The most commonly used ones are free of cost and require less bandwidth - Google products. Google has made available Google Meet and its entire suite of Documents such as Google Sheets, Google Docs, including Google Forms.

Google Meet is an online teleconferencing platform that allows multiple users to communicate at the same time. This also provides chat functionality and the ability to share content to make teaching more interactive. Other Google offerings such as Docs and Spreadsheet allow collaboration and ease of use. Google Forms is a handy tool to administer surveys and collect data. Quizzes created on google forms emerged as an essential tool in the assessment of students and their learning.

Microsoft has also entered the online teaching domain through ***Teams***. While Teams initially adopted teams only for Corporate Users, it has quickly become a key player in the teaching industry. It offers teleconferencing including video conferencing, ability to score documents through channels and folders, create teams and tag all members through tags, whiteboarding, custom LMS integrations, custom backgrounds and a dashboard that generates insights. Its complete offerings position it as a beneficial solution for all its members. Microsoft Teams can perform each requirement of meetings, documents sharing, file storage, whiteboarding, notifications and data analytics in one place.

Zoom is another tool that has dramatically enhanced the online teaching experience. Zoom has two offerings: Zoom Meetings and Webinars. Meetings are more useful for conversation-based lectures, while Webinars are used when delivering a one-way learning module. Zoom Meetings have practical features that make online teaching easier, such as breakout rooms. These help teachers separate the students into groups, much like you would do in a typical classroom setting. Each group can communicate with each other, and the teacher can be notified to come in and help if needed. The challenge with Zoom meetings is that it only allows 45 mins of interaction unless you have a paid subscription making it costly for all students and organizations to adopt.

Quizizz is a creativity software company used in class, group works, pre-test review, exams, unit test, and impromptu tests. It allows students and teachers to be online at the same time. It uses a quiz-style teaching and learning method where a user answers questions independently and contends with other users on the same quiz. Students can use Quizizz on any electronic device and browse, similar to, laptops, iPads and smartphones. Wikipedia mentions that Quizizz can be used as a 'check' tool that explains how the students know about the material. Teachers can use Quizizz to assign students homework.

The tools, as mentioned earlier, have made the online education process teacher and student-friendly. These tools have made it easier for teachers to be in touch with their growth throughout the learning process. It is always said that the only constant feature of this world is its inconsistency. During this pandemic, when the traditional modes were challenged; technology emerged as a rescuer to teaching.

Explanation Map: A Tool for Visualizing the Logical Structure of Explanations of Science Questions, Phenomena or Demonstrations

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Introduction

In this article, a format of a map or flowchart is presented that makes it useful for visualising explanations of the multitude of science phenomena or textbook questions that students come across in their daily life, or seen on the internet, or their curriculum. The paper presents a case for the need for a communication tool suited for science-related explanations. The potential benefits of using this tool for STEM education are listed. In the end, a prior experience of using this tool in a classroom setting is described.

Background

Following is an account of how I was inspired to create an explanation map. In the Grade 7 online Physics class, the topic of discussion was pressure in gases and liquids. To demonstrate that the atmosphere exerts tremendous pressure on us, I showed the students a video in which a plastic bottle gets crushed when a certain sequence of steps is followed (Fig. 1).

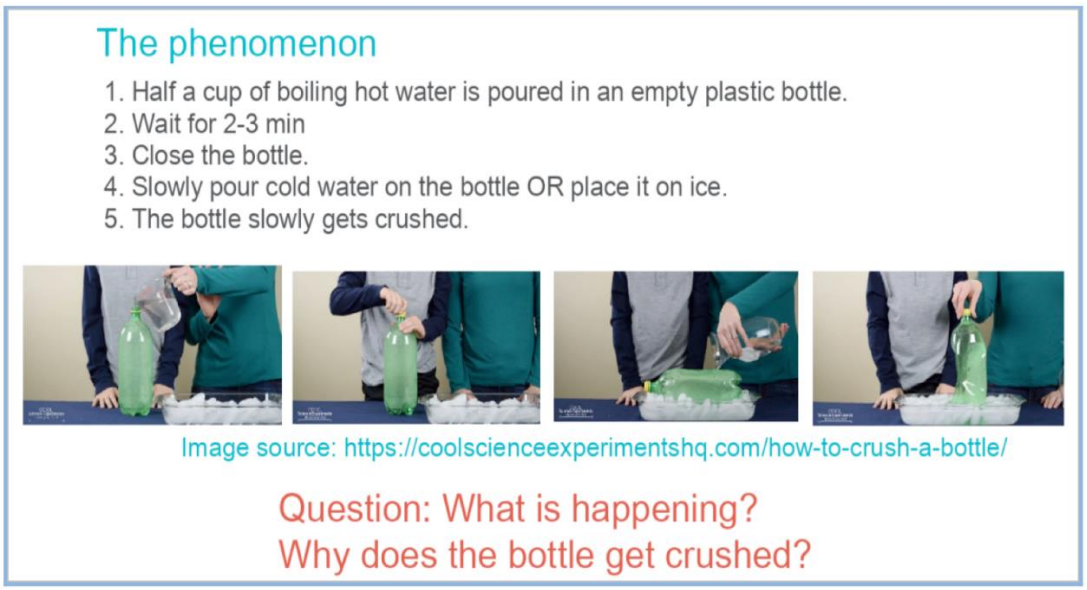

Fig.1 An image or video of the demo or phenomenon, that acts as a hook.

This is the well-known demonstration wherein steam trapped inside the bottle condenses and the bottle crushes due to atmospheric pressure. I asked the students to explain the crushing bottle demo, and some students did give excellent explanations. But there were still some points that seemed to be unclear. So, after the class, I thought of presenting the explanation in the form of connected boxes of text accompanied by doodles. Using Google Jamboard, I created an Explanation Map and shared it with the students (Fig. 2).

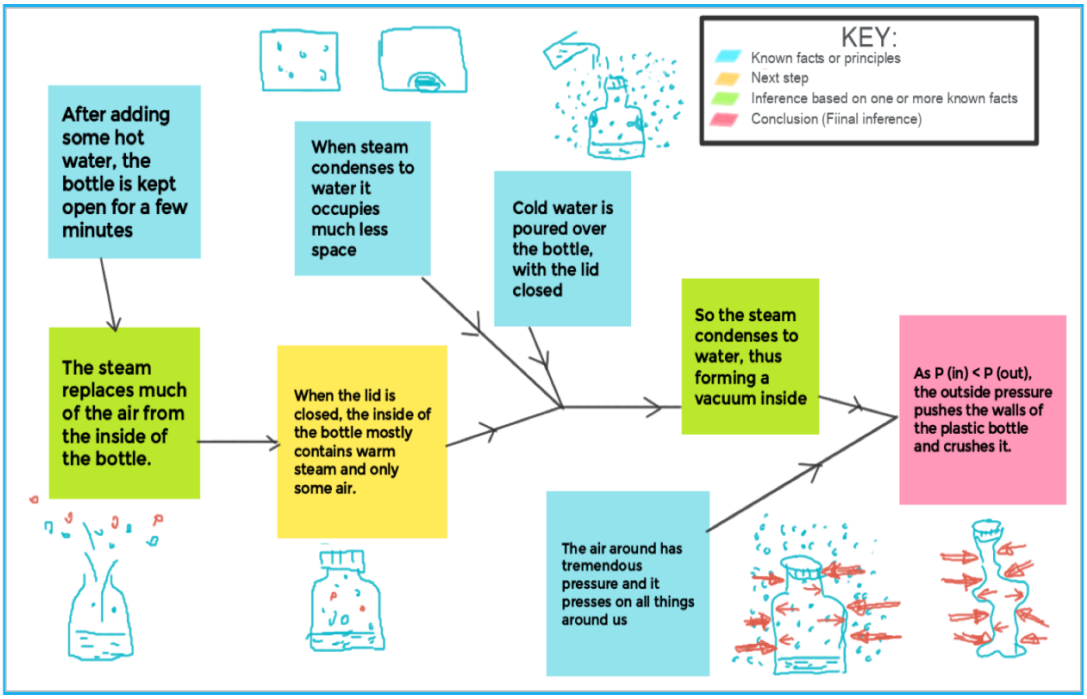

Fig.2 An Explanation Map that attempts to explain why the bottle gets crushed.

The need for a communication format for explanations: Every field has its vocabulary and its language, for example, Western Music is written with notes placed on horizontal lines, Maths has its symbols and rules, Particle Physics has Feynman diagrams, Computer Algorithms have flow charts. Yet when it comes to explanations (which is one type of a question besides other types like description, numerical problem solving, derivations etc.) in science, there seems to be no accepted form of communication to easily and effectively convey the logical structure of an explanation.

Explanations are generally given as statements (written or spoken), which demands good command over the language to convey complex ideas. Suppose a student finds it challenging to convey the explanation well using only sentences. In that case, it adversely affects the student's confidence, and the teacher will face difficulty in correctly assessing the student's understanding.

Though visual devices like a mind map, concept map [5] or argument map [1] are well known, and these formats can be used in multiple fields, there is no specific format developed for visually communicating explanations of phenomena encountered in science (at least not in my knowledge). While a mind map is a useful tool for organizing the concepts of a topic, it has a diverging structure; on the other hand, an Explanation map will be suitable for presenting Science explanations. It has a converging flow chart structure. Also, if one compares arguments with an explanation, these are different, for example, refer [1, 3 & 4].

A format of a map is proposed here that may bridge these gaps. An example is seen in Fig. 2.
Format of an Explanation Map: Four types of colour coded boxes or nodes:

1. One or more Known facts: scientific principles or a procedure in the demo;
2. Inferences based on one or more known facts;

3. Intermediate steps: Anything that does not fall in the other three categories;
4. Conclusion: Usually a final, single inference.

The other distinguishing feature of this map is that each box may consist of some or all of three modes of concept representation, and such boxes would be connected in a logical structure, thus an Explanation Map on the whole will consist of four information representation elements (instead of sentences alone):

1. Text;
2. Visuals – photos/ doodles/ diagrams;
3. Mathematical content- formulas/ equations/ graphs
4. The logical flow structure of the connected boxes.

This format is obviously time consuming to create and takes up more space in the notebook compared to writing plain sentences, but its potential advantages may far outweigh these disadvantages.

Potential Advantages and Suggestions for Science/ Stem Education

1. Format is suitable for answering questions of How and Why type.
2. Promotes analytical and critical thinking: This format breaks up an explanation into its components which encourages analytical thinking. Here is an example that illustrates how the explanation map is suitable for critical thinking as well. For instance, if one of the 'known facts' boxes is struck off or modified, then the inference that follows will get modified too. For example in Fig. 2 if we modify the known fact that "there is air around us", to "the bottle is on a planet where there is very little air, or in space", then the new inference would be that even though there is vacuum inside, the bottle will not get crushed. This logical thinking makes it clear to the student that simply having vacuum inside will not crush a bottle- and most importantly that vacuum does not 'suck' things in, which is a common misconception. Thus one explanation map helps to answer other related questions.
3. Students can work individually or collaborate. In collaboration, students can discuss, move the boxes around, play with the connected logical structure of the boxes and strengths of team members is leveraged using Google Jamboard Tool. Some students may write well, some draw well, and some are good at mathematical treatment.
4. Teachers can see maps created by students and provide specific feedback about the scientific principles or facts that are used as starting assumptions, logical flow, language, diagrams, and mathematical treatment.
5. Whole brain thinking: Use of language + diagrams/ doodles + maths/ graphs + logical flow structure would promote integrated learning.
6. Creative visualization of Science models with doodles: Apart from illustrating what is visible, the doodles are specially meant for creative visualization of abstract concepts like: 'air is made of very tiny particles called molecules and the particles are continuously moving around and colliding with each other and with things around'. In Fig. 2 the air has been shown as dots- more dots outside the bottle than inside. The red arrows indicate that these are colliding with the

walls. This would help create a stronger connection with the science models and its textual description, definitions and formulas.

7. Accessibility: These maps can be made with stationery material or digitally- both are possible in a low cost way. The relevance of such a tool is more so in the online classroom era. One logistical issue is about drawing doodles- this requires either scanning drawings done on paper, which is tedious, or drawing using a digital tablet, which is moderately expensive.
8. Question difficulty can be tuned without oversimplifying the answer. This format can be used across grades and also in college or in research. For junior grades I propose that some scaffolding could be given. The boxes could be provided with the text and elements already filled in. Then the students could arrange these in a logical structure. Or maybe the entire map is given and a few elements (text, drawings, math expressions) are left blank for the students to fill in. As the students progress through the grades they could be given more independence in creating an entire explanation map and with greater complexity.
9. Numerical problems and derivations can also be structured in the form of an Explanation Map, as there are multiple assumptions or values that are known and sometimes multiple concepts are involved and all these can be combined together in a logical sequence to give an answer.
10. This idea is partly inspired by the objectives of NEP (National Education Policy, India, 2020), and will hopefully cater to the expectations of STEM education.

Preliminary experience of using explanation map in the classroom

The explanation map format was introduced to grade 11 students by displaying the images as shown in Fig. 1 and Fig. 2, as a sample and describing its feature of connected blocks. Then a question on standing waves that required an explanation as well as some calculations, was assigned from the grade 11 Physics textbook. As an answer, an Explanation Map was required to be created, working in pairs by collaborating on Google Jamboard. Following are comments of some students:

- Sneha said she has started to apply the format to other explanation questions. She appreciated the way the logical structure became visible.
- Kanika: "It helped me connect the ideas, steps and reasoning"
- Adithya said that this method would specially work for a 4 mark (or more) question where complexity is involved. He said that he could see how different concepts came together.

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Teaching Computer Science

With Special Reference To Fractals in The Garden

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Introduction:

In our IWSA garden we see many trees, plants, vegetables, fruits and flowers which have very complex and irregular shapes. Some of these objects in the garden are broccoli, amazon lily, thistle flower, fern, pine apple, sun flower, rose flower, succulent and many more. In computer ~~science~~ these are known as Fractals .

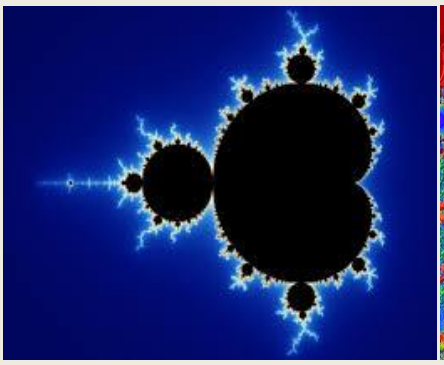
Fractals are the shapes that seem to appear ~~as~~ irregular and chaotic but they can be constructed and modelled mathematically. Fractal is a kind of mathematical shape or pattern generated by using a computer, using a different kind of geometry known as Fractal Geometry. Fractal designs are artistically and aesthetically ~~are~~ very beautiful and pleasing to eyes.

Examples of fractals in Nature are abundant: mountains, clouds, rivers network, snowflakes, cauliflower, and broccoli. In human body system of blood vessels, airways in lungs, nervous system all can be defined as fractals. In all this same basic shape is repeated over and over again at smaller scales.

Techniques of generating fractals:

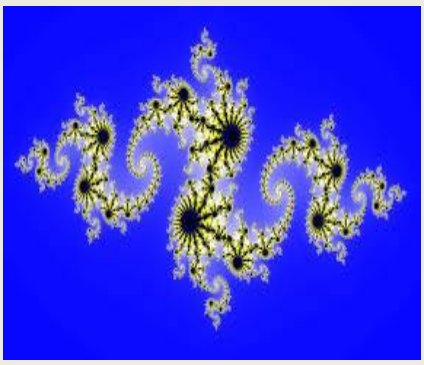
Fractals can be generated by using mainly three techniques:

(1) Mandelbrot fractals: Examples are Julia Fractal, Douady Rabbit, Mandelbulb etc



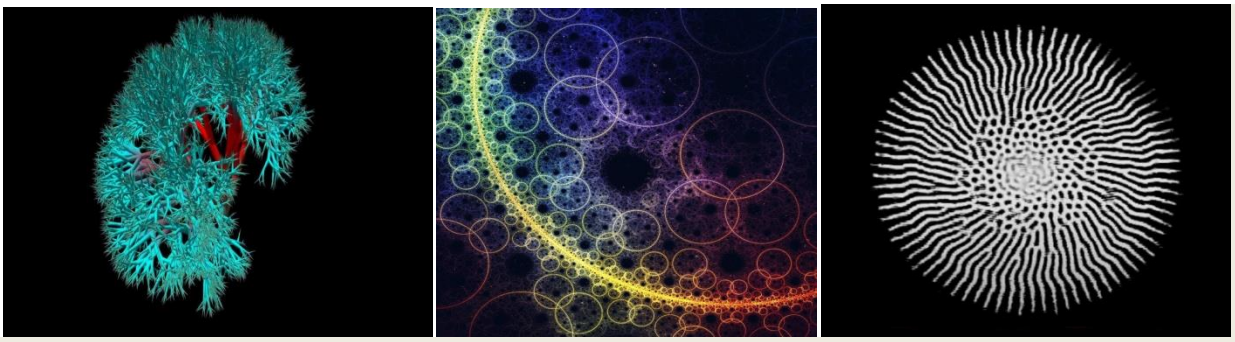
Mandelbrot fractal

Julia Fractal



Julia Fractal

(2) Random (stochastic) fractal. Some Examples are



3) Iterative function system (IFS) fractal

In these fractals, there is a fixed geometric replacement rule.

Some examples are Cantor set, Sierpinski triangle, Koch snowflake, dragoncurve,

Manger Sponge etc.

IFS in the Garden

Following images from the garden are examples of Iterative Function System fractals.

These natural shapes of the above objects can also be defined and constructed mathematically.

Fractals have two key properties:

1. Self similarities:

Self similarity means If you divide a fractal pattern into parts you get a nearly identical reduced-size copy of the whole.

In other words, an image can be magnified many times, and after every step of magnification, you will eventually see the same shape as the start.

A tree is approximately self-similar. That is, a small piece of the tree looks somewhat like an entire tree. Thus, any complex tree is formed by repeating a simple process over and over again.

Following pictures shows the self similarity in Broccoli

2. Non-integer dimension: In Euclidean Geometry i.e. in Classic Geometry, we have

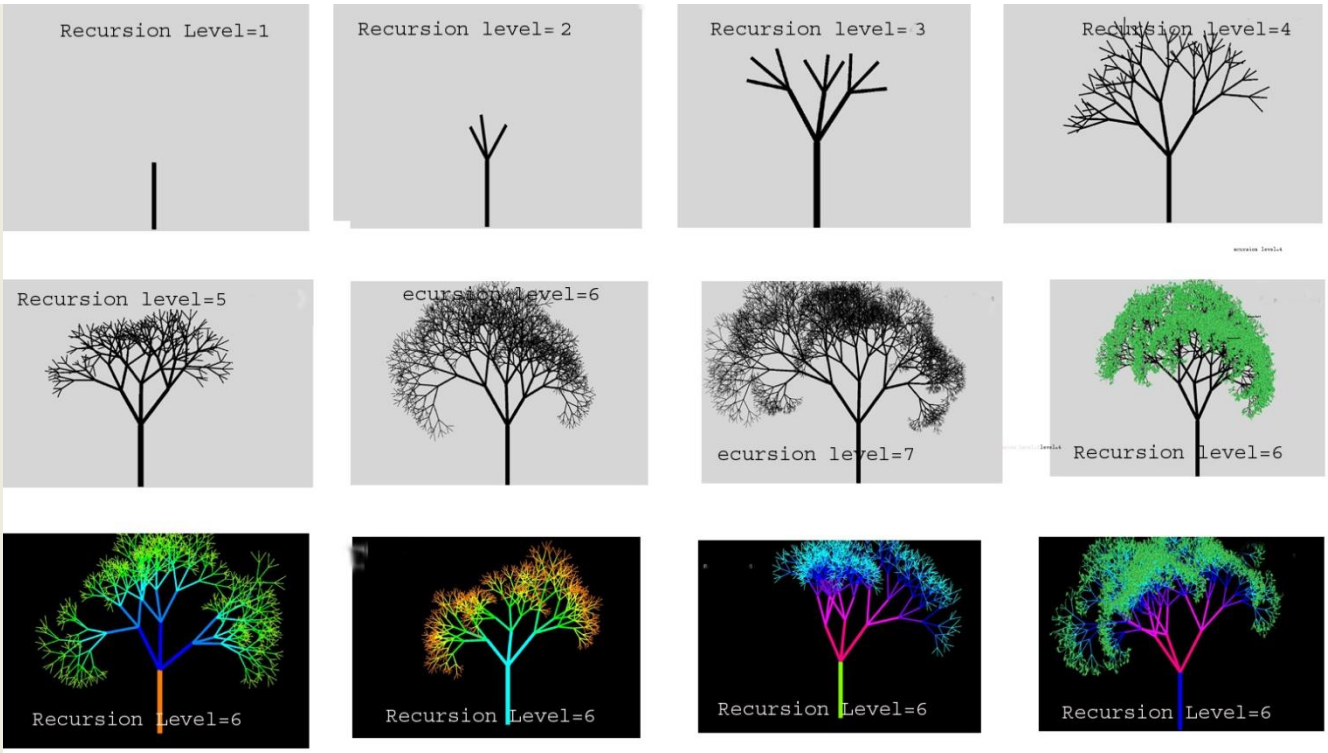
0,1, 2 and 3 dimensional objects. In Classic geometry the dimension of any object cannot be a fractional number.

But in fractal geometry, the dimension of a fractal object may be any fractional number like 1.62 or 2.45 0r 3.82 etc.

Practical for generating computer tree and Koch Snow-flakes

(a) Tree: Tree is one example of IFS. The algorithm by which a tree grows is as follows:

A sprout comes out of the ground, and then splits into number of branches. Each of these branches then splits again into new n number of branches, and each of these branches splits again into new branches. This is known as recursion in computer language. At each point in this process, it is as if two/three/more new, smaller trees emerge, and the new branches can be thought of as the trunks of the next generation of trees. So, a large tree can be seen as a collection of many smaller trees of various sizes. Thus, the repetition of branching that forms the tree also generates the tree's self-similarity.

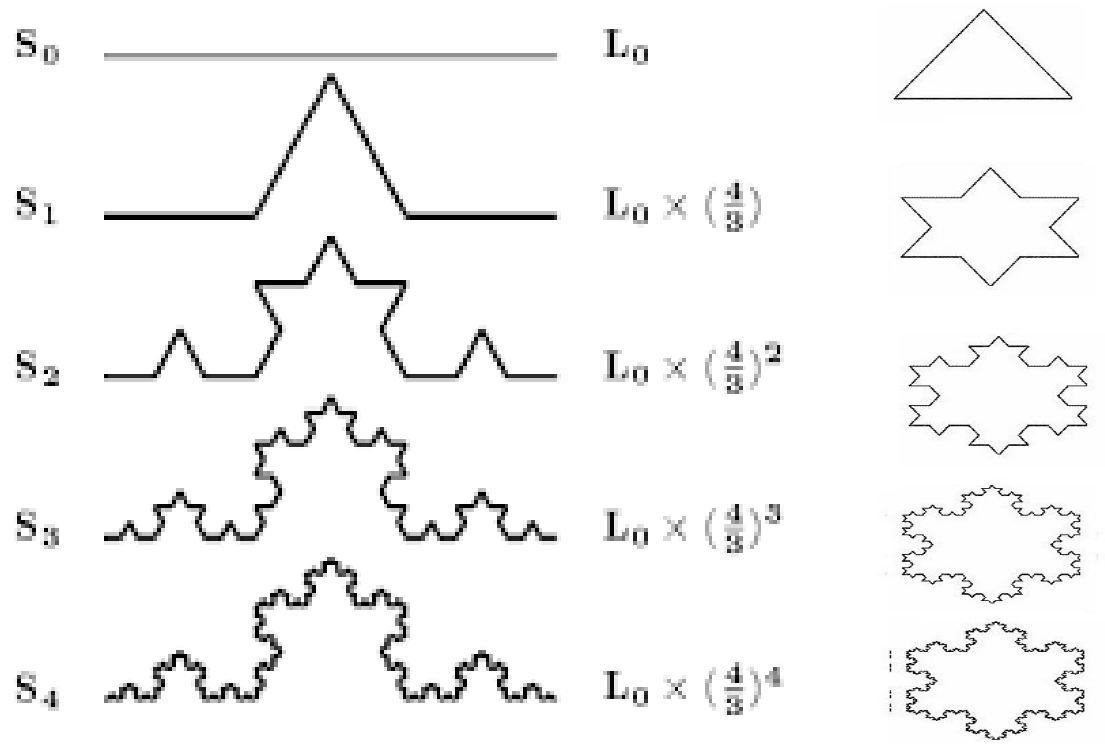


The step-by-step construction of tree is displayed on line. In above computer-generated trees, many variations are possible: some are as follows,

- Starting with the trunk, Instead of straight line, It can be a curved line as we see in the fern and next branches are also curved.
- The number of branches may vary from minimum 2 to any finite number.
- The angle of next branch may vary from 0 to 360 degrees.
- In each node in next recursion, the number of branches and span of the angle may be same or may be different.
- The length of branch, emerging from stem may be same or different at each level of recursion.
- Thousands and thousands variations are possible, because in each iteration all the variables (number of branches, their span, length ratio) may be changed in random order also.

It can be observed that in nature, trees of same species look similar but they are not exactly same. This is like the human face and human finger prints. No two human being have exactly same face or same finger prints.

b) Koch Snowflakes:



The algorithm of Koch-Snowflake is:

Draw a straight line of length L0. Divide it into three equal line segments, each is which is of length L0/3. Now replace middle line segment by two lines, making an angle of 60 degree to each other as shown in above diagram.

Now the total length of the line becomes L0*(4/3).

Repeat this algorithm again on each of the smaller line segment in each subsequent

Level. From 4^{th} level onwards beautiful snow flake is formed.

Some more examples of fractals:

In computer generated fractal patterns the number of iteration is very very large, it is in billions, depending upon the computing power of the processor but in nature the number of iterations for the real tree is finite and does not exceed after a certain limit.Some computer-generated ferns and flowers are as shown below:

Conclusion: The basic concept of fractals design is explained in simplified manner and students are able to understand the above concepts. The students can do the coding in any computer language. Students will get inspiration to create the computer model of various natural objects they see around them in the garden like trees, plants, vegetables, flowers, fruits and also other natural objects like mountains, clouds, rivers network, snowflakes ,blood circulation system in our body , airways in human respiratory system etc. Models of various natural objects and infinite number of beautiful fractals designs can be created using modern computers.

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Developing Critical Thinking Through Online Teaching During COVID-19

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Introduction

Critical thinking is a hot topic in education today, but often little is said about what it is. One obstacle that has prevented us from making further progress in critical thinking education in recent decades has been our inability to understand the concept well enough to determine how to integrate critical thinking skills into the curriculum. On top of it, COVID-19 situation has worsened students' effective learning, even though every significant possible step has been taken through online teaching. Thus, teachers must develop critical thinking skills among students and allow them to use these skills and inspire them to continue practising them independently. In this article, we try to address some of the problems associated with online teaching and possible solutions to achieve critical thinking skills among students.

Critical Thinking and Online Teaching

Students around the world are experiencing the changing effects of coronavirus as classrooms move online and courses and curricula extend into the summer. As students lose one-on-one learning experience offered in the classroom, several online learning platforms help students finish the semester strongly by offering free online courses. [1] The new National Education Policy (NEP) adopted speaks of the need to be ready for digital and online education, adding that the digital divide must be eliminated so that everyone can fully benefit from such methods. This policy is a futuristic one and aims to make education accessible to all students, teachers and educational institutions. [2] Overall, national education policy is quite revolutionary: it aims to shift the focus from traditional learning to critical thinking and promote problem-solving skills among students. This vision of a knowledge society leads to an objective change in curricula by minimizing formal learning and instead promoting problem-solving. [3] The new policy not only revises the curriculum but also promotes experiential learning and critical thinking. In school education, policymakers focus on reworking the essential foundations that have been preserved and placing them in the hands of students by hand - in activities such as reading, writing, mathematics, and science. It is committed to a more holistic approach to education, focusing on developing pupils' skills, abilities and abilities. [4]

We are facing a reality in which the only one in ten educators teaches critical thinking, and this pandemic has undeniable implications for education. Critical thinking can help us to overcome the changes and challenges presented by COVID 19. Still, these difficulties alone cannot explain the

cognitive dissonance that exists when we claim that critical thinking is a critical aspect of our students' future readiness. This shows the importance of equipping teachers, administrators, students, parents and other educators with knowledge and skills in critical thinking. [5] If online teacher migration is implemented rapidly following the outbreak of COVID 19, students' fears must be allayed by ensuring that students can participate actively and effectively in online learning. However, the ability to begin and complete an entire period of online teaching can change. Teachers who insist on keeping learning online until safety prevails everywhere will not be able to do so, even if they can use online platforms. [6] Students and teachers face the challenge of adapting to an online learning environment seemingly overnight. It is essential to adjust the teaching speed to ensure effective provision of teaching information. For students, whether pre-primary or higher education, online teaching can do a lot to help them learn. Some teachers consider using online tools to solve problems such as "online teaching" and "learning offline to self-learning." [7]

According to the teachers, online learning's attention span is even shorter than that of face-to-face sessions, which are also supported by the literature. The survey shows that teachers need to adjust the pace of online teaching to consider the environment of a completely different classroom. By using reverse learning modalities in the classroom, such as short lectures and improving teacher-student interaction, we can increase the number of student-teacher interactions and their teaching quality. [8] Online tools have various options when developing their online curricula, including interactive learning technologies such as virtual reality, augmented reality and mobile devices. This is a great opportunity for teachers to incorporate these technologies and programs into their curriculum, making it easier for them to engage their online learning students.

Even if a group of students has access to devices and tools to participate in online classes at home, teachers cannot interact with students in real-time. Students who cannot attend online courses face barriers because there is no physical space for teachers to conduct online classes at home. Those who have access to online courses from institutions have difficulty accessing Internet connection, Internet access and access for students and parents. [9] The lack of interaction between students makes it difficult to assess, which tends to hamper online learning. Another challenge is to keep students, especially the young ones, who are most likely to run away from online teaching. Teachers face challenges because the free online platforms are unsafe and teachers don't know how to use the security features. [10] If face-to-face classrooms are not possible, online teaching, especially for higher grades, is an obvious option. But for those who need to complete their primary and secondary education online, the prospects for online education seem lacklustre. The number of students who theoretically have access to online lessons depends on their ability to use a mobile phone instead of a computer. We believe that online education requires synchronized learning, synchronized learning occurring on other online platforms where the teacher works directly with the students. [11]

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Augmenting Science Education Resources Of Vigyan Pratibha Through Videos

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Introduction

The Vigyan Pratibha program being conducted under the academic leadership of the Homi Bhabha Centre for Science Education (HBCSE) works at the school level to nurture the enquiry-based method of learning science in interested students. “Videos” discussed in this paper were thought to be an important addition to the existing educational resources of Vigyan Pratibha. This paper summarizes the pedagogical and practical considerations in the efforts to create videos as a supporting educational material. Though this effort assumes more importance in the light of the current Covid-19 pandemic-induced online learning, its scope and utility are much beyond it.

The Vigyan Pratibha program[1] aims to strengthen school science education in India. This is mainly achieved by designing and generating documents called ‘Learning Units’ based on topics related to school curriculum. The learning units present these topics in a different perspective, linking them with observations and phenomena in daily life. These are discussed in the form of multiple short sessions with school students and school teachers (separately), using a constructivist approach[2] - a lot of opportunities are provided for students/teachers to collect and analyse data meaningfully as opposed to the more common lecture format with limited such opportunities. To further strengthen the learning unit modules, creation of video resources was undertaken. These short videos, called ‘support videos’, were meant to be useful for both students and teachers. Making the science videos pedagogically sound, within a limited time frame (about five minutes) was found to be a challenging and non-trivial task. This is a work in progress - videos in various science topics are currently being worked upon, with some near the finishing stage, before being made public.

The making of a science video

There are many steps involved in the planning and creation of support videos. They are highlighted below.

1. Selection of topic: The topics which were based on actual experimentation were chosen as the initial candidates for video creation. Some examples are ‘Parallax’, ‘Pinhole camera’, ‘Components of wood ash’, ‘An experiment in measuring volumes’, ‘Bringing back shine to copper’.

2. Content planning: Plans of the videos were chalked out considering the content in the learning units. Additional dimensions were also planned, so that the learning unit and the video were not repetitions but could complement each other productively.

3. Video shooting of experimental sections: Much of science at school level is experimental in nature, requiring students to associate with the content by performing experiments. In many cases, visualisation of the actual experimental set up is key to complete understanding. Creating an analogous model of the experiment is also important, especially for topics in physics. Hence, detailed experimental demonstrations were an important part of support videos.

To cater to the online mode of teaching and learning, appropriate modifications were thought out in the experiments using materials available at home. Pilot experiments were performed to make sure the modifications were robust. It was hoped that teachers and students would find such 'adapted' experiments easy to perform by themselves even at home. Additionally, these modifications enriched the existing learning unit and would be worth retaining in future physical classroom/laboratory sessions of the learning units. Common problems and challenges encountered in creating the experimental set up were also included along with simple tricks to resolve them. The experimental details were video shot either at HBCSE laboratories or at homes of team members.

4. Script and visuals generation: A detailed written script for the support video was generated. The language was simple but scientific. Words were chosen carefully with minimum jargon, so as to match the learning stage of the students (for example: a video meant to be discussed with grade 8 students did not contain terms/concepts which are introduced to them only in grade 10). Relevant schematics were created to explain certain phenomena. Appropriate images and animations helped bring a good balance of visual and audio communication. The entire script went through multiple revisions to accommodate comments from team members.

5. Pedagogical aspects: One of the main distinguishing features of the support videos was that these were to be unlike most videos available online. Instead of being just information-rich, these were planned to be pedagogy-rich. Thus, especially the teachers could have meaningful take-aways from these videos. Daily-life examples or experiences were included so that the viewer could identify with the scientific phenomena being discussed. For example, scenes of wood ash accumulation as seen in village ''chulhas' (traditional cooking stoves), or images of tarnished copper vessels in kitchens were used for the support videos for 'Components of wood ash' and 'Bringing back shine to copper', respectively.

The videos contained some facts and demonstrations leading into each other by way of questions. The questions were not rote-learning based, but analytical. For example: questions commonly began with "Do you think that....?", "What may happen if ...?", "Have you observed ...?" Sometimes, the questions had more than one answer depending on the thought process chosen by the viewer, but they were never open-ended. This was especially true for some chemistry-based videos. Direct answers were not given at all, but appropriate cues and clues were provided at every stage so as to trigger the thinking process of the viewers. Even the experimental demonstrations were made such that the final result or effect was not shown, to ensure that the viewers would be

curious about the outcome and try the experiment themselves. The viewers were also encouraged to change certain variables in their experimental set up and observe the effects, especially in optics related topics in physics (e.g., 'Pinhole camera'). Thus, the entire effort was to make the videos an exercise in self-discovery, where the viewers would only get appropriate prompts and directions to 'discover' the concept by themselves.

The videos can also be looked upon as opportunities for teachers to create 'flipped classrooms'3, wherein the students by themselves, get acquainted with the topic at their homes, before it is discussed in class. The 'flipped' approach is relatively new and uncommon in India. The videos therefore, can encourage teachers to attempt it, at least occasionally.

6. Voice over and assembly: The voice over was done in English, ensuring clarity and correct tone. Appropriate pauses were included so as to give the viewers a real-like experience online. All the video and audio parts were assembled together in a systematic fashion using video editing software. The videos do not follow any set pattern, each has its own flavour and dimensions, depending on the topic.

7. Vetting: The ready videos are planned to be vetted by external experts before they are made available on the Vigyan Pratibha website.

Conclusion and Way Forward

The generation of support videos is an attempt to explore the audio-visual medium to nurture the critical thinking approach among school students and teachers. The videos help build interest in the topic, familiarise the viewers with the contents of the corresponding learning unit and also encourage them to read the detailed learning unit. It is hoped that the teachers will be able to give their students a complete 'experience' of the topic by making use of the support video, the learning unit and their own facilitation methods. This effort has been a learning experience for the Vigyan Pratibha team too and feedback from the end users will be important in shaping future videos.

The videos shall be made available in the very near future. Though currently in English, there is a potential for these to be dubbed in various regional languages for better reach throughout India.

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Science in Virtual Classroom - Challenges and Remedies

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The COVID-19 pandemic forced all educational institutes worldwide to shut down their campuses indefinitely and move their educational activities onto online platforms. In the midst of the pandemic teachers were forced to pivot their instruction online to allow teaching-learning to continue and along with it came lots of challenges. Challenges make us better, not bitter and teachers like always tried to give their best, for their students' well being by improving their knowledge and skills in technological aspects, designing creative and engaging methods of teaching and being available for their students all the time.

Introduction

Technology has impacted almost every aspect of our life today, and education is no exception. Though the contribution of technology was less before the covid-19 pandemic, it was still quite noticeable. But now, it has become the necessity of the hour. When covid-19 entered into this world, it changed the way we live, interact, work, teach and learn. It has been more challenging for teachers and students as they had to learn how to adapt to the new kind of teaching-learning and shift from the traditional classroom to online classroom. Before the pandemic, PowerPoint presentations, pictures, videos and movies were used to support the teacher's lectures. Still, in this online teaching mode, they have become the primary teaching aids and teacher's explanation has taken a back seat.

Challenges and Remedies in teaching science online:

There are certain challenges that teachers have been facing in virtual classrooms which makes a teacher's jobs challenging and full of responsibility. But someone rightly said, "challenges are what make our life interesting and overcoming them makes them meaningful". With every challenge, there is a remedy that we can use to overcome it. Few of the challenges and the remedies to overcome them are as follows:

Passive students: Online teaching-learning can make students passive observers rather than active participants. They might feel disconnected with the utility of the content taught to them in the virtual classroom if the lesson is not well crafted. Since science is a study of many abstract things, just listening to the teacher's explanation and not applying the knowledge they've received do not fulfill the purpose.

Remedies to make passive students active in online classroom

Augmented reality: Augmented reality allows students to explore and learn the topic in detail. Eg. Chemistry AR apps allow students to visualize and interact with the spatial structure of a molecule using a marker object held in the hand. Anatomy students can visualize different systems of the human body in three dimensions.

Flipped classroom: Flipped classroom helps to deal with mixed levels of students facing varying type of difficulties, and have differentiated learning styles. In a flipped classroom, students watch online lectures, collaborate in online discussions, or carry out research at home while engaging in concepts in the classroom with the guidance of the teacher.

Collaborative Learning : Interaction between teachers & students and students & students during the instructional process is what makes education successful. This collaborative engagement is a must while learning science as it promotes deeper understanding of the content that is being taught. But this collaboration can be difficult to achieve if the students are not physically present together.

Remedies for collaborative learning within the Online Classroom:

Breakout Room: We can attempt to mimic the collaborative case problems solving via the 'breakout room' function on a video conferencing platform. Students can be divided into groups of four or five during discussions and can solve in-class case problems, using the whiteboard feature to annotate their solutions. Such ability is essential for an equations-heavy subject like physics, only challenge to this practice is the students should have an appropriate set-up, such as a stylus-enabled laptop or writing device. Instructors are able to go to the different breakout rooms to observe the ongoing discussions.

Whiteboard: Using whiteboard and by sharing the screen students can solve problems and write equations along with the teachers on the board. While using a whiteboard, try and use markers of different colours to write formulae, derivations, and drawings to make it more engaging.

Science Demonstration: No science lesson especially physics can be completed without live demonstrations and activities connecting theory with real world experiences. Unfortunately, the online mode of instruction drastically limits the wonder and visual impact to the students steered by such live demonstrations.

Remedy for replication of Science demonstration in online classroom

Virtual laboratory: Through virtual science lab games and engineering simulation software, learners can interact with elements, machines, and interfaces before or instead of trying them out in real life. The idea of virtual laboratories is to provide students a chance to perform experiments using the internet and visual aids without having the equipment at their end.

GeoGebra: Use GeoGebra for an interactive geometry, algebra, statistics and calculus application, intended for learning and teaching mathematics and science from primary school to university level.

Hand-on Experiences: It becomes way more difficult for a science teacher to conduct a lesson through the online platform as she is not able to provide her students with hands on experiences which are a big part of science education.

Remedy for replication of Hand-on experiences in online classroom :

Experiments at home :

A. Teachers demonstration: Teachers can carefully curate demonstrations that fit easily into the field of view of the camera (and picked up by the microphone, if sound is involved), without having the instructor to move about significantly. Eg. Demonstration of topic of forces, resonance, etc.

B. Experiment by Students: Even there are some experiments that students can conduct at home. Eg. In Biology students can isolate strawberry DNA in their online classes or conduct class experiment on the properties of enzymes using rennin (found in Junket tablets) or bromelain (from pineapples) which works similarly when performed at home with plastic cups replacing laboratory glassware

Missed the lecture or keeping up the pace: Understanding the concept of science is challenging sometimes especially if students have missed any lectures or students who want to learn at their own pace.

Remedy for the students who have missed lecture during virtual classroom

Videos: Teaching math online can be challenging but there are ways to make it a productive and positive experience. Recording online lectures and making them available to the students can help the weaker and absentee students to catch up with the topic.

To teach organic chemistry, a program that allows us to write on the screen should be used. We can use PowerPoint to record. Then export the videos as mp4's and upload them to YouTube. If we want our face to be in the picture, we can use ScreenCast O'Matic or Zoom to record. Being digital natives, the learners view online classes as 'edutainment than education' and continually set new learning goals for themselves. It also allows learners to learn at their own pace, revisiting the lesson as many times as they wish before moving on to the next stage. Games and Gamification: Games are effective tools for scaffolding concepts and simulating real-world experience. Among the simplest ways to engage students in gamified learning is to try web resources such as Kahoot, Quizlet, Quizziz, Socrative etc.

Conclusion

Online learning is not about ONE pedagogical model but an aggregation of various models and hence each teaching faculty needs to be massively re-trained and oriented for online teaching-learning mode. Online learning is just NOT a library of video lectures and e-books that converts class-notes into PDFs but its also creating high quality digitized learning content which must be contextualized to make learning interesting and engaging and doing this takes a rare skill set.

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Learning Chemistry (Science) Practical Using Kitchen Chemicals for Secondary Students

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Introduction

Science subject involves learning organisation, critical thinking, observation, analysis, reasoning etc. Science practicals are performed in the laboratory, but this pandemic made it difficult to enjoy science with practical experience. Students perform acid-base science activities using the resources available in our house. This develops interest, analysing, critical thinking and reasoning ability among students towards science learning. "Science" is a term used to describe the systematic way to learn, explore, and analyse a concept or a topic. It has answers to questions like what, how, why etc. Science deals with understanding and explaining the various phenomena happening around us like the ripening of fruits, photosynthesis, the ringing of the phone, etc. Science is a subject which deals with day-to-day activities happening around us. From primary school, students learn the subject in which they deal with topics like a human body, health and hygiene, healthy habits etc. These are taught in school and implemented in daily life, which later turns out to be habits. So science involves practical learning of concepts and not just remembering the concepts.

The year 2020 marked as a pandemic year. This pandemic just brought our routine life to a standstill. Schools, offices, public transport etc. came to a halt all over the world. Initially, it was thought to be for a short period but looking at the disease schools' impacts is declared shut for an extended period. But learning is not shut or close to students. Instead, it opens up a new platform for learning and teaching called "online learning". Online teaching is of two types. One is live lectures, and the other is creating an online course using a MOOC platform.

Teachers, students and parents were new to this type of learning and not much aware of its benefits. We are used to our regular school which involves going to school, learning, communicating, and interacting, etc. which is approximately 5 hours 5/6 days a week. MOOC is an online course in which an instructor creates topic or concept-wise modules and made available to the students' community learning with a self-pace. These courses are available in form of videos, pdf documents, discussion forum, quiz, online test for evaluation etc. It consists of learning of a topic and evaluation or assessments also.

Teaching online is a new task for teachers. They have to explore the technical part of it. Teaching is to share and make the student understand the various (science) concepts. It was to shift from traditional chalk and board to virtual platforms using power-point presentations, E-tools like Google slides, Google forms, jamboards, mentimeter, kahoot quiz etc for sharing notes and evaluating students. Science involves not only teaching theoretical concepts but also to perform practical activities. Science imparts critical, analytical and reasoning attitudes to students. Perform

science practical without a proper laboratory and the availability of chemicals is one difficulty in learning science. This article shares information about acid-base activities performed by students using available resources at home during the pandemic period.

Objectives

1. To teach students to perform science (chemistry) activities using kitchen chemicals.
2. To develop analytical skills and critical thinking skills among students of secondary students.
3. To evaluate and analyze the concept learning of the students.

Chemistry Practical performed using kitchen chemistry on a virtual platform at RFSKK. Chemistry subject involves learning acid-base concepts. This is related to daily life substances. This paper is put forth to make chemistry fun learning with hands-on activities. These activities are simple and are performed by students using the resources available in the kitchen (or at home). During lockdown as schools were closed and students were missing the key element of learning science that is laboratory activities. These activities help to develop concept understanding, creativity while performing activities.

Acid-base activities are performed by students under teachers' instruction and with the help of parents as and when required. These activities are initiated with pre and post activity discussions. Pre-lab session involves watching the video related to the activity to understand the procedure and arrangements of the material required. Post lab activity involves discussion about the activity performed. It includes discussion about difficulties or challenges faced during performing activity, observations, variation obtained by different students. Following are the activities performed by students

1. Acid-base activity

Aim: To study the turmeric (natural indicator) in the given sample solutions.

Material required: Glass or plastic container, soap solution, vinegar, dropper or spoon, turmeric, dropper, etc.

Procedure:

- Take 2 glass or plastic containers, label them as samples as acid and base. Add the sample solution 2-3 mL to the respective container.
- Add 2-3 drops of turmeric solution and observe the colour change.
- All solutions were prepared in water.

Observation: Turmeric turns red in basic solution and yellow in acidic solution.

Note: Only two sample solutions are suggested but this activity can be performed using a variety of acid and base samples like tomato juice, lemon juice, face wash soap, egg shell etc.

This activity was fun learning among students. They performed the activity and shared their results in form of photos or videos. One of the important observations as it was suggested to perform activity using washing powder solution which gives intense colour change of the indicator. Students perform similar activities using different soap solutions like hand-wash, bathing soap etc and share their observations and results. This helps to develop interest in learning the topic, enhance critical thinking and analytical reasoning among students. This was the first activity performed and which brought interactive discussion among students.

Fig.1: Labelling of material (acid-base) samples & indicator

Fig. 2: Addition of vinegar in baking soda and washing powder

2. Neutralization Reaction Activity

Aim: To perform neutralization reactions using kitchen chemicals.

Material requirements: Glass or plastic container, soap solution, vinegar, dropper or spoon dropper turmeric etc.,

Procedure:

- Take a glass or plastic container and add 5-10 mL soap or baking powder solution to it. Add 2-4 drops of turmeric solution—the colour of solution changes to red.
- Add vinegar solution in parts to the above mixture and note your observation. The red colour slowly changes to yellow with the evolution of (CO_2) gas.

Fig.3: Labelling of material (acid-base) samples

Fig. 4: Addition of indicator to different samples.

Observation:

Addition of indicator (turmeric solution) to base turns red. Addition of an acid (vinegar) slowly changes to yellow. There is an evolution of (CO_2) gas due to which solution may spill out from the container.

These activities were performed by students and shared their work in the form of images or videos. They added titles to the images and voice-over or subtitles to the videos they recorded over the phone. These were small activities students performed. They were performed at home using a daily substance, so no fear of the usage of chemicals. Secondly, they can perform activity multiple times at their ease and bring up new ideas and observations. Creating videos also helps to develop resources as well. This also helps to look for ICT tools for the activities as well.

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Challenges in Teaching Science in the Online Mode

Anju Pental, Reliance Foundation School, Koparkhairane

Introduction

"The new normal" which is nothing but adaptation to the pandemic situation has forced the 'work from house' and 'learn from home', a reality. Learning from home creates a challenging transformation and comes with its own set of limitations. The subjects that included audio-visual aid and demonstrations threw a more complex challenge for the teachers and the students. The traditional way of teaching with the help of tools and instruments further exposing the children to the laboratory "to do it yourself" method came under serious threats. However, to overcome this, the teaching, coupled with simulations tried to replace the traditional teaching method to some extent.

Creation of resources: The sudden shift to e-learning has been stressful for both the teachers and the students. When we cannot just stand in front of our class and teach, we have to rely on additional resources to do the job for us, and those take time to create. All the verbal instructions have to be translated into simple written documents that all students can access and understand. Recording our own instructions and posting it online is one way to make the task simple. We have to be dedicated to quality learning.

Adaptation to technology: Teachers are striving to adapt to the new form of teaching by equipping themselves with technical skills. Along with adaptation to technology, there are many other challenges. Science is always learnt by doing and practising. It is always by experiential learning that we can recall the content and skills. In online mode, generally, the hands-on part is missing and theoretical content and external lessons are being delivered. As a result, students cannot practice, and the learning process does not reach its full potential. The teaching of science is purely based on real-life situations. Simulators can be used to practice and experiment and hence put their new knowledge and skills to practical use. At the high school level quality lab equipment is essential for experimentation. Seeing is believing. Viewing stars through a telescope puts our galaxy within reach and makes the heaven more intriguing. Learning science requires deep engagement and inquiry through hands-on or virtual activities.

To learn science is to do it, read it, write it, draw it and talk about it through hands-on mini-experiments that stand missing on a virtual platform. However, these can be taken through online videos. Teachers focus on phenomena-based instructions in which an observable natural event is used to provoke students' inquiry. Explore – before – explain method can be used to develop a student's conceptual understanding. Exploration serves as the core of their conceptual understanding of science and hooks for learning through the lesson. Explorations that produce data, at home, may seem to be the biggest challenge. Teachers are investing lots of time to design

creative hands-on investigatory models using household items. They are also using PhET simulations and online videos to make science more engaging.

Lack of teaching and learning resources

One of the challenges that we as teachers faced was, non-availability of teaching and learning resources and materials. When we teach the concept of elasticity in metals, we study metal properties such as malleability, ductility, etc. We generally learn these by visiting a blacksmith. He demonstrates how metals can be either drawn into wires or change the sizes. But in online mode, this was made clear to the students by showing them the related videos. As an example, a fundamental concept of physics, the motion of a charged particle in a magnetic field was explained to students with the help of the following 3 – D simulation: https://ophysics.com/em8.html

The working of a reflecting type telescope was explained using the following simulation. The students found it very interesting and understood the working of the Cassegrain telescope.

(https://interactives.ck12.org/simulations/physics/cassegaintelescope/app/index.html\lang=en&referrer=ck12Launcher&backUrl=https://interactives.ck12.org/simulations/physics.html)

Screen casting – We used the screen video recorder to explain certain complex concepts. Setting up the right atmosphere: Working online is a challenge. Staying at home can be a nightmare without self-discipline and a suitable environment. We have to set up a workplace which is meant for work only. This space should be friendly and inviting and peaceful. It should be free of distractions like television, other family members or household chores. Natural lighting and a comfortable chair can help in setting up our ideal work environment. A science class needs total concentration of the student.

Isolation: There is no doubt that the new equilibrium of learning will transform the understanding of science concepts. Learning from home can be lonely. Some students can begin to feel a strong sense of isolation that slowly erodes their desire to learn. Many students will find that they miss school. Isolation can also undermine many of the instructional strategies that we take for granted in our classroom. The online platforms lack opportunities to do group work, class discussions, and collaborative activities, which are an essential part of students' learning of science and engagement. Teachers need to connect with their students through discussions.

Lack of humanity and warmth: Online teaching is difficult for teachers, but it is even more challenging for students. They have gone from class-rooms to bedrooms and kitchen tables where there are maximum distractions, and expert support is not always on hand. Hence the students might feel frustrated. Not having a teacher physically in front of them can make some students nervous. Students often get depressed due to lack of human contact, the absence of a teacher and an inability to discuss experiments with their classmates. Students need a physical space where they can resolve their queries.

Internet connection: There are many advantages of technology, but we also need to recognize their limitations. All homes are not the same in terms of internet access. Teachers can inform parents beforehand about the same, and such students can be accommodated ahead of time. Sometimes a little technical glitch can prevent them from getting started. Many of them are not proficient with tackling unfamiliar software. If the students face any connectivity issue, they should have the platform to report such technical issues, which we can resolve with IT support. No video, hyperlink or text can take the place of student-teacher interaction. We have to find ways to connect with the students. As teachers, we will have to allow students to take the lead in controlling challenges with curiosity and creativity. This will help build a community of critical thinkers who will desire to solve this world's problems. Isn't that what science is all about? Thankfully, as teachers, we can do a few things to keep things personable in the online environment. Here's a few:

- Use video calls and videos of you and students; we can't be robots who only communicate via text.
- We can coordinate virtual group activities, chats, discussions boards, and cloud tools for collaboration.
- Students who are at risk of disengagement need special attention.

The ultimate goal is to acquire knowledge which helps students to get well settled in their life. Teachers teach them to create and respect their responsibilities and to manage their time better. These are all trades that students will find useful even later in life and acquire success in any field.

Developing Online Interactive Environment for Science Teaching and Learning Digital Cartoon Storytelling

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Introduction

With the technological developments in the 21st century, it is now necessary to effectively integrate technical renovations into teaching-learning environments. Several approaches allow the integration of technology into teaching-learning environments. One of these approaches is digital cartoon storytelling.

Digital cartoon storytelling serves as a popular pedagogical tool to be used by the teachers in different fields for the students from all age groups. These activities are entertaining and attract students' attention. Cartoons bring in life into the dull pages of the books and the hidden secrets of the subject. Cartoons are eye-catching, and digital cartoon storytelling has been explored as a way to bridge the gap between facts and understanding.

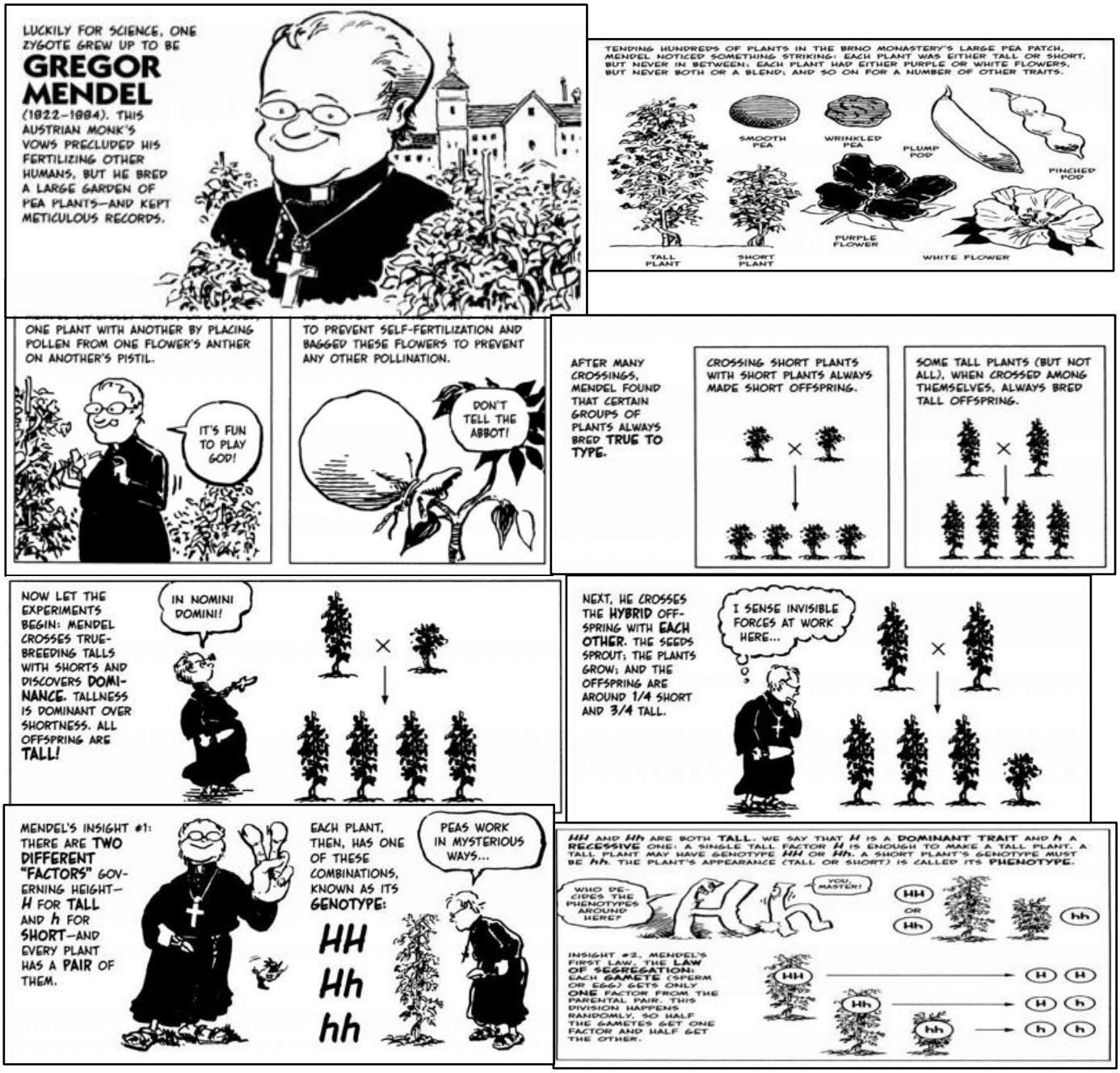
Benefits of Cartoon Storytelling as an Instructional Strategy in Biology

Improves Memory: Individuals can learn new facts from stories without prior exposure via traditional means with a similar degree of success as learning through conventional lecture methods. It helps to retain the information for an extended period.

Leads to a Better Understanding: There are many topics which cannot be theoretically understood. They need practical experiences or real-life examples. Comic stories can help a lot in this situation. Teachers can easily use a comic story to narrate a topic. With the use of cartoon characters and callouts, teachers can easily cook up a story. This way, the students will be able to understand the burdensome subjects comfortably.

Improves the Student-Teacher Relationship: All children like cartoons. If the teacher uses a digital cartoon story to teach the students, they will start to like the teacher. Once this relation is developed, the students will be more attentive to the teacher and listen to every word spoken by the teacher. It will enhance the student-teacher bond.

We can incorporate digital cartoon storytelling to deliver certain topics in biology like Gregor Mendel's work in the following way.



Source: The Cartoon Guide to Biology by Larry Gonick, David Wessner

It is important to consider cartoon storytelling as an alternative method to teach scientific information to students to improve contextual meaning and help construct the necessary schemata to incorporate the information. It thus makes learning easier and enjoyable for the students.

Challenges in Teaching Science in the Online Mode

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Introduction

The Covid-19 pandemic has disrupted the education sector globally. Classes have been suspended to enforce social distancing and educational institutions, from schools to universities, have shifted to online methods of teaching and evaluation. As the number of cases continues to rise, there is no certainty about when normalcy will be restored. This has encouraged some sort of a permanent tilt, if not a complete shift, to online education. The new National Education Policy (NEP) 2020 also talks about being ready for digital and online education, although it adds a rider that the digital divide must be eliminated to fully benefit from such method. The following paper analyses difficulties in online education and also tries to provide suggestions for the same.

A wholesale shift to online education is not just dependent on access to devices and the internet. It is also about nuances. The current crisis has turned the focus on the flaws in the system -- lack of access to quality education for all, lack of inclusive education, scarcity of qualified teachers and low focus on life skills.

Research

While e-learning emerged as the biggest savior in the wake of the closure of educational institutions, it has come with its own set of challenges.

Online Education or e-Learning has been implemented in three ways :

1.Mobile , Laptops , Computers (Internet Connectivity) in regions where Internet access is easy

2.Mobile , TV, Computers (Without Internet connectivity) through Digital Repository.

3.Mobile phones through Telephone conversation.

Although Online & Digital Education is the need of the hour but it cannot be implemented successfully without addressing the challenges.

Three-fourths of students in India did not have access to the internet at home, according to a 2017-18 all-India NSO survey. The share of those who did not have computers, including devices such as palm-tops and tablets, was much greater--89%.While mobiles can be useful in listening to

online lectures, they are not the ideal medium when it comes to writing exams or even assignments. Lack of access to the internet and devices has also created a gap in digital literacy. As many as 76% of students in India in the 5-35 age group did not know how to use a computer. The share of those who did not know how to use the internet was 74.5%.

Some teachers are not familiar with the new format of education. They are not well trained for online education classes. Besides this, it is not necessary that a good classroom teacher will be a good teacher in the online classroom.

There are a limited number of resources available to conduct an online examination in India. Besides this, there is a limitation for the number of questions that can be asked in the exam.

Science as a subject can not be taught in the digital education space as the online education system is more of a type of screen-based learning system which restricts the students to perform practicals and the amount of skills and critical thinking that need to be developed is also restricted.

The internet connectivity is not good everywhere. There are some cities of India where the people are still using 2G or 3G internet connection.

Resolution A: Diksha-Swayam

The existing e-learning platforms such as DIKSHA and SWAYAM shall be extended to provide teachers with a user-friendly and well-structured environment. These platforms must be updated with some set of tools such as two-way audio interface and two-way video that can help the teachers to conduct online classing and monitor the progress of students.

Resolution B. Digital Infrastructure

Creation of public digital and interoperable infrastructure that can be utilized by multiple platforms. This new digital

infrastructure must be created by keeping in mind that the technology-based solutions provided through it do not become outdated with time.

Resolution C. Training for Teachers

Teachers must be trained to use online learning tools and platforms. Besides this, they shall also be trained with additional skills so that they can manage the online platform themselves. The training must emphasis on improving the teacher-student engagement through the online content and resources.

Resolution D. Virtual Labs

Some digital platforms such as SWAYAM, SWAYAMPRABHA and DIKSHA shall be asked to create some virtual labs where students can practice their theoretical knowledge. These labs shall be equipped with all tools for improving the hands-on experiment-based learning experiences. Besides this, access shall be provided to students and teachers so that they can learn through the tablet or any other electronic gadget.

Resolution E. Digital repository, Content creation and Dissemination

A digital repository must be created which will include Learning Games & Simulations, Virtual Reality and Augmented Reality. The system must be provided with the public system for rating by the user to analyze the quality and effectiveness. Besides this, some fun based learning tools like gamification of Science principles must be created with operating instructions. These instructions will be available in different languages so that everyone can understand it easily. A secure backup system will also be provided for the dissemination of e-content to students.

Conclusion

Online education opens up a lot of possibilities for students and teachers alike. All our policies and interventions with regard to online education should strive to be inclusive. Good vision, sincere efforts and time will show us the way ahead.

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Transition in Pedagogy of Science Teaching and Active Learning

Suja P. Joseph and Pooja Vadiye, Utpal Shanghvi Global School and Prabhavati Padamshi Soni International Junior College, Mumbai

"Change is situational. Transition, on the other hand, is psychological. It is not those events but rather the inner reorientation or self-redefinition that you have to go through in order to incorporate any of those changes into your life. Without a transition, a change is just a rearrangement of the furniture. Unless transition happens, the change won't work."

-- William Bridges

The academic year 2020-21 worldwide from the pre-school to the high school from undergraduates to postgraduates and so forth underwent a total paradigm -shift in the way the teachers and students perceived the teaching-learning experiences. The teachers willingly / unwillingly had to take the aid of technology in totality. This compulsive shift from chalk and blackboard to a stylus and Jam board became inevitable. More than the students, the teachers had to revisit their pedagogical approaches to deliver their subject curriculum successfully. Teaching hasn't been easy during this pandemic situation, and teaching Science is no exception. Despite the constant changing learning environments, the science teachers were continuously evolving to the challenges with resilience and resistance to give support to the learners.

Planning, Designing, and Executing the delivery of the structured science curriculum from the closed rooms and the experimental labs in a school/college to the openness in the students own surroundings (from formal to an informal set up) was a task taken up initially with a lot of handholding via the leadership teams and the IT dept. Making the teachers comfortable using the various online resources and strategies was of utmost priority to make the educational cycle work without a break.

We utilized the limited preparation time to think-pair-share the best online practices within the faculty groups. A collaborative approach with peer support and professional development webinars on remote teaching/learning helped this transition in the pedagogy of science teaching, which became a new normal. Effective Science Instruction involves a student-centred rather than teacher centered approach. The focus was on using the 5E Instructional Model and explore strategies that became part of online lesson delivery.

5E Instructional Model: Lesson Objectives

Every stage had Time bound Lesson Objectives.

Engage **–** Engaging learners via media resources or guided activity using various real-world examples in context to their content, followed by a guided questioning strategy to help build on the learners' previous knowledge and clarify any misconceptions. This stage is vital as the teacher teaches the students to ask questions leading to the explore stage. Lesson taught: Types of Materials (Treasure Hunt Game: learners get engaged in collecting resources from their surroundings and share experiences in class).

Explore **--** The teacher encourages the learners via direct inquiry or guided inquiry to select various resources in finding answers as they work through the exploration stage. In this stage, students try uncovering scientific understanding, conduct investigations, Analyze data, text, and other media resources, and collect evidence to support their scientific explanation. Lessons taught: Concept of sink and Float (self-exploration by learner within surrounding Followed by live class interactions); Sound (activity has done DIY musical instruments)

Explain **–** The learners construct their scientific explanations individually or within small groups, either written or orally, with other virtual class classmates. Feedback from peer students and the teacher help refine the explanations and develop a more profound understanding of the knowledge gained. Lessons taught: 3D tools (AR simulations and visual stimulation (PHET)); Learning Classification of vertebrates (AR simulations on Animals and their characteristics to make learning in the real-time were utilized by learners).

Elaborate **--** The learners are given a study from the real world application after demonstrating their proficiency in the above stages. Students interpret data from the graphs, share responses based on their findings. Lessons taught: DNA extraction; Partition coefficient (case study on Inuit mothers feeding PCB contaminated breast milk).

Evaluate **--** In this stage, students are encouraged to review their concept learning through the formal and informal assessment strategy using tech tools like google quizzes, Kahoot, spin the wheel, polls, Mentimeter, Quizlet, chat-bomb etc. The formative and summative Assessment is part of every stage of the model to build on the Active Learning experiences. It helps the learners to reflect on their growth before and after each lesson.

The 5Es are not actually in a linear progression. Engaging is not separate from exploring. Exploring is not necessarily different from explaining. Part of exploring requires elaborating. All

of these elements require evaluation with self-reflection. This learning model was monitored continuously by conducting online observations by the team leaders and giving constant feedback for improvement. We received feedback from the students and the parents.

Showcasing the work in a visually appealing manner had its limitations in a physical classroom, in a virtual class, this is taken care of beautifully. The online data is continuously being collected and used for further considerations and streamlining the learners' learning needs. Flexibility and implementing a changed pedagogy that supports learners to be responsible for their learning by minimizing the undue importance of marks (especially in the lower classes) has become mandatory especially in the New Generation Science Standards. A pedagogy that supports the transition from STEM SKILLS to STEAM SKILLS where the focus is on the importance of learning science out of curiosity and interests will develop lifelong learners irrespective of the ever-changing world environment. Changes previously considered difficult or impossible to implement possible after all. We must continuously seize the opportunity to find new ways to address the learning crisis and keep bringing about a set of sustainable solutions.

Learning Garden – An Avenue to Science

Sweedle Cerejo-Shivkar, Ambika Janakiraman, Srirupa Mukherjee, Tripta Tewari, Vijaya Chakravarty, Indian Women Scientists' Association (IWSA), Navi Mumbai

Introduction

Science is an inseparable part of human lives. To understand the subject, one has to adopt audio as well as visual aids. Learning Garden is one such unique initiative to inspire, motivate and create scientific temper amongst students. It is an experiential open school which enhances the science experience. An assemblage of different biology, chemistry and ecology; Learning Garden houses flora and fauna and is an open-air laboratory that exhibits interaction between various biotic and abiotic factors, thus encouraging inclusive education. The resource exchange amongst butterflies, birds and plants is a visual experience. The plant-animal interaction is a very basis of life which the students have been learning.

According to the pedagogy principle, with increased involvement of senses, learning experiences get more enhanced. It is said "We listen, we forget. We read and write; we remember more. But when we do the things ourselves, we remember them throughout life." Based on this and to encourage inclusive and integrated education under recent United Nations' Sustainable Development Goals; the Learning Garden initiative of IWSA was designed and developed in June 2018. This paper highlights how the LG like the one set at IWSA aims at multidisciplinary experimental-learning process involving all streams of natural sciences and ecology, ethical practices, other arts subjects etc. following education policy of Government of India.

The IWSA Learning Garden (LG) – A Platform for Inclusive and Integrated Learning: Learning Garden is an assemblage of more than 500 species of plants from various biogeographical regions in India – like Western Ghats, Deccan Peninsula, etc. This available green space is segregated into 70 sections depending on the specificities of plants. The biogeographical sub-sections form an Oikos for various species. This, in turn, attracts birds and butterflies which are excellent agents to understand interactions between various nature's elements. Till date, 21 and 20 species of butterflies and birds were recorded respectively1. There is another microfauna like ants, bees, bugs, beetles and spiders housed in the garden. Plant-animal interaction is an interesting phenomenon for teachers and students. They learn the species diversity, interdependence on plant life, the food web and phenology and breeding cycles of our flora and fauna. Learning Garden is an ecosystem with a sustainable design which exhibits butterflies feeding on nectariferous plants. They lay eggs on their larval food plants. Thus their life cycles continue, and population increases. Different birds with varied feeding patterns (granivorous, nectarivorous, scavengers) use various LG to feed strata. Our cities are fast losing their green cover, which the fauna need who take refuge in them. LG attempts to conserve the species; has initiated a seed bank and spread

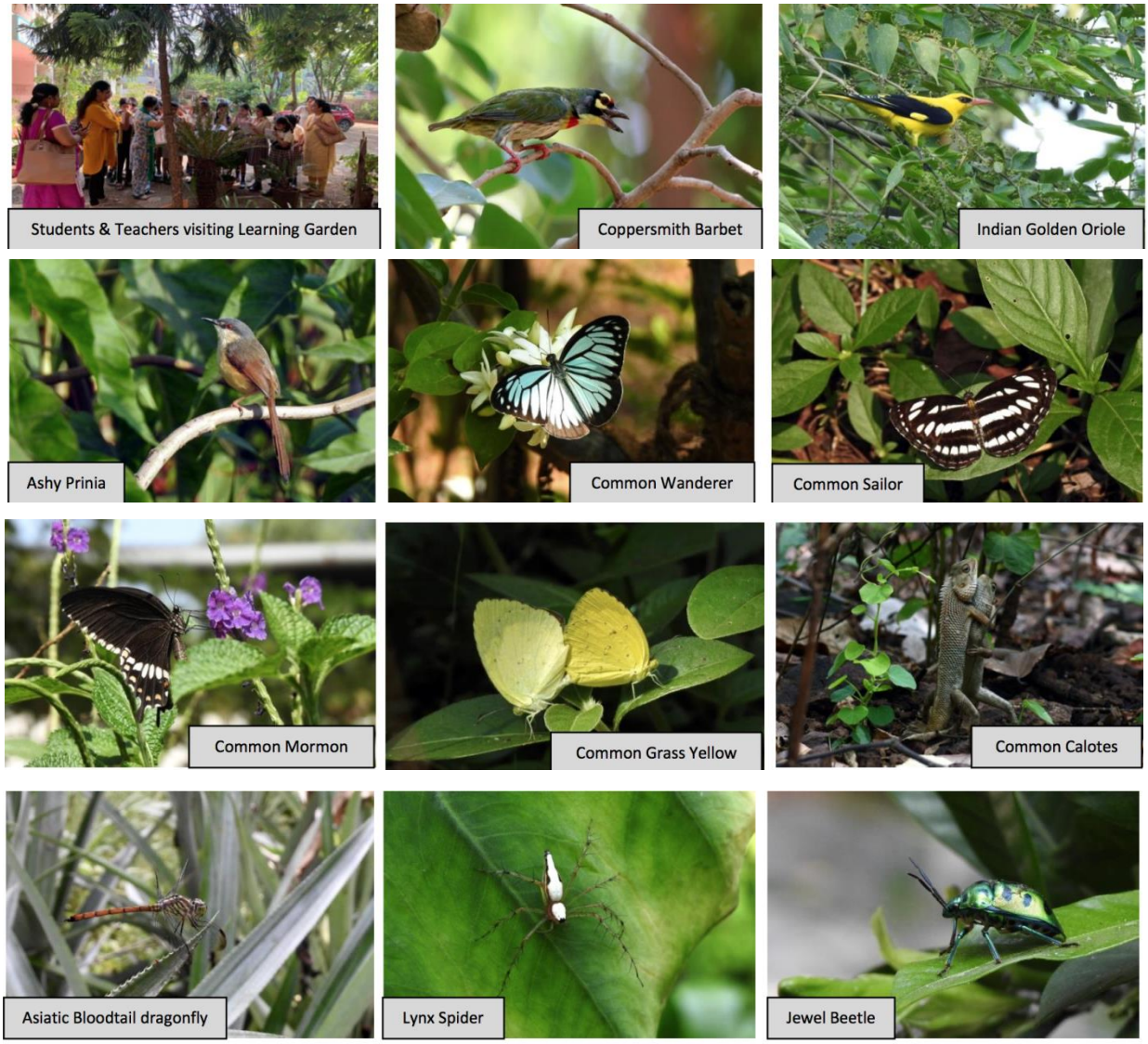
awareness about the importance of garden-based learning. The facilitators and nurturers of LG, are experts from various backgrounds and eminent scientists, making the whole programme an exhilarating experience.

The subjects learnt through audio-visual aids are art, botany, chemistry, geography, geology, history, mathematics, physics, medicine, sociology and zoology. In Chemistry, the experiments of indicator solution and pH paper preparation from plant sources like purple cabbage, hibiscus and turmeric were performed. These were used in testing the pH levels (acidic or alkaline) of common fruits and vegetables. In Botany, for example, the xerophytes exhibited in the LG help in understanding the modifications and adaptations of the desert biome flora. Along with these experiments, LG caters and targets the teacher and student communities through garden trails, workshops, lectures, exhibitions, and educational materials. These joyful activities inspire and motivate the groups to learn, understand, and assimilate various scientific concepts, including the beauty and importance of nature. However, due to the Corona pandemic, these had to be stopped, and LG had to bring classrooms to virtual platforms. In July 2020, LG started reaching out through webinars, virtual meetings and virtual classrooms with the help of previously recorded video clippings or photographic evidence to conduct a virtual tour of the Garden. The LG has started a unique initiative of an online Member Enrichment Programme (MEP). This is done through webinars which nourish and nurture the participants with its special topics and themes. Some of the presentation details are mentioned in Annexure 1.

Garden-based learning gives access to nature and provides children with a myriad cognitive, emotional, and physical benefits - such as increased concentration, improved academic performance, reduced stress and aggression levels, and reduced risk of obesity2. Though the students miss the touch-feel-smell and observation part of learning in the online class, they get the visuals and corresponding explanations. Garden-based learning can create a greater sensitivity and appreciation for life and a deeper understanding of the interconnectedness of all living organisms3. Educators, parents and public officials should embrace this method as an effective learning environment, and attempt to replicate the broad design of LG, if possible.

Conclusion

Students in the urban set-up are deprived of many natural phenomena. The present pandemic situation has kept students from attending schools physically and visiting green spaces leading to various disadvantages. The attempt to inculcate scientific temper through online classes is successful only to a certain extent. Learning Garden strives to bring students near nature and instil scientific temper in them; the approach is to Appreciate and Respect.



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Teaching through a Virtual tour -an online module of the Learning Garden at IWSA

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Indian Women Scientists' Association, Vashi

Over the short span of two years IWSA's Learning Garden had served as an important center for outdoor education and sustainability in Navi Mumbai area. In Pre-Covid times, school and college students used to visit the garden and were taught about the various Bio-geographical sections of the garden. During these visits all five senses were involved in the process of learning. There were the visual delights of color and the excitement of feeling the different textures of leaves & flowers. One could experience the ecstasy of interacting with butterflies, jewel bugs and other tiny creatures coexisting in the garden's ecosystem. The fragrance of fresh growth and moist earth and the different tastes of fresh flowers and leaves from the garden were a source of joy. The horror of a dying plant due to over/under watering or due to some unknown disease made the learning process a wholesome and completely fulfilling experience. Young and old, members and staff, visitors and hostel inmates all loved to watch and learn from our little outdoor laboratory. It had become a means of amalgamating all arms of IWSA into one.

Now Covid has changed our lives such that online learning has become a new normal. Every new way of life has its limitations but it is a challenge to our creativity to turn these into assets! So, we decided to plan a virtual tour of our garden. These would retain the visitors at our garden and the tour could help augment the offline teaching once the actual visits returned! These virtual tours would come in handy during monsoon breaks too.

We found that videos and games make the online classes more engaging. We plan to have a module for each section of our Learning Garden under the umbrella of the Virtual tour of our Learning Garden. Each module would last for a maximum of 15 or 20 minutes. Short modules would ensure the tours are taken gradually, well within healthy screen-time regulations. One such tour of the garden would be to have small modules with pictures of the plants in a particular section with information regarding these plants. Earlier we had attempted to do this by using Plants map site. This proved to be very good tool for cataloguing but was not very exciting for the uninitiated.

In order to start planning our virtual tour we tried getting feedback from both teachers and students. Both parties missed the mute signal that eye to eye contact in the actual classroom gave. In these days of isolation, an interactive way of learning would be more welcome and garners attention. If a dash of poetry or drama or story telling is added, it reignites the slowly diminishing

interest, as screen time engagement increases. These tours can have tiny question boxes and activities (either online or offline DIYs like post a similar picture of the plant at a different stage from the internet or draw a cartoon) before moving ahead so concepts/principles are recollected. Botany, History, Geography, Chemistry and many other subjects could branch out from these sections. The possibilities of connecting are limited only by our imagination and willingness to explore.

Indoor Air purifying Plants at IWSA

Money

Sansevieri

Spider plant

Dracaena

Areca Palm

Dieffenbachia

Syngonium

Gold-Dieffenbachia

Song of India

At the learning garden, we are well aware that only two senses of color and sound will be engaged whilst using an online learning platform. One method of creating an engaging virtual tour is using 360degree photographs and 3D images. These are widely being used on social media platforms. The next generation is already familiar with apps that can generate such images and photographs as is evident from their posts therein. We can divert such dexterity into education by making them turn in photographs of plants, flowers, leaves not only from our garden sections, but also exchange information on same or similar specimens elsewhere in the country or across the globe. Thus, they will learn how environments affect the specimens and their curiosities would be aroused from such comparisons. Their fertile imagination will provide some answers and they will set off on little expeditions of discovery. Augmented reality and Virtual reality are slowly making inroads in education worldwide and we have to bring our children abreast with the latest developments. We can use Google AR and VR to enhance our virtual tours and study the external as well as internal processes inside the plants, interaction with their ecosystem and show the children how our actions affect them. We have a module with our Indoor Air purifying plants using pictures of plants from the section to demonstrate in a virtual tour using GoogleVR. The details about these plants exist in the description box when the plant is clicked in the module. There is a narrative describing the plant as well. The entire module is bound by a small skit showing how these plants can be used to fight the indoor air pollution menace. This module can be taught in chapters on environment, chemistry and botany.

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The Making of an Engaging and Effective Science Learning Experience

Dr. Reeshma Suri, The Teacher Foundation, Mumbai

Introduction

The pandemic has changed not only the way we live but also the way we teach. With students being stuck at home, and all learning moving to our screens, teachers have found it increasingly difficult to bridge the gap and to make learning engaging for their classes. This observation-based essay is meant to give insight into the various forms of teaching that have emerged over India's lockdown. It will also provide relief for the teachers by suggesting tools and strategies, to engage with students.

The onslaught of the Covid-19 pandemic exposed many cracks in the world of education in India. It forced teachers to adapt and learn new tools to engage their learners effectively. While most teachers started with sharing YouTube videos over messaging services such as WhatsApp, the more informed ones created their videos and shared them with their learners. Some schools gradually moved on to integrating learning management systems like Canvas, Moodle and many more. There was a steep rise in the use of online interactive platforms like Zoom and Google meet. Despite the onslaught of tech-in-teaching, a vast majority of the teachers were not aware of technology, safety features or ways of making their lessons engaging. Students were loaded with either video lessons to watch and answer the questions or watch the live lecture-based classes and copy down notes posted online. Studies became monotonous, and students were passive and disengaged.

As the Senior Coordinator for teacher training and support at The Teacher Foundation, Mumbai, I observed many online classes during the lockdown period, both in the affordable private sector schools and international schools. This essay is based on the observations across the various spectrum of schools and teacher inputs and the experience gained from different training sessions experienced and conducted for the teacher empowerment.

Observations

Teachers engaged students in three main types of learning experiences depending on the availability of resources and their expertise in handling the online tools.

1. Asynchronous Learning: Asynchronous Learning occurs when teaching materials are posted online, and learners work through them in their own time, communicating with each other and the teacher via discussion boards, WhatsApp or forums even by email. With an asynchronous teaching mode, the learners can work at their own pace and at times of day, which are convenient for them. This is more suited for students and teachers in remote areas and can face difficulties such as a

stable internet connection or a lack of mobile/personal devices for every member in the house. However, it left students isolated and teachers confused about the achievement of the learning objectives.

2. Synchronous Learning: Both learner and the teacher are present at the same time, generally through the use of a video conferencing mechanism. In a virtual classroom, both teachers and learners can ask questions and participate in the discussion in real-time, just like in a face-to-face class. However, poor internet connectivity, lack of proper devices, time management, lack of teacher awareness about safety features and the comfort with online platforms can be major pitfalls in the process.

3. Blended Learning Approach: It combines both synchronous and asynchronous ways of learning. Short video/audio/textual content and some points to ponder are provided in advance to the students. This prepares the learners for the lesson before they come to the class by giving them a background, laying the path for better class discussions. During the synchronous session, students can discuss, debate, solve and refine their learning. Post the online session; some other tasks are assigned to reinforce the concept, thus ensuring that the learners have had a chance to absorb the lesson to the best of their capabilities. This approach engages all types of learners: oratory, practical, or those who may prefer reading.

All the above-listed techniques have one common goal: to make learning exciting and engage our learners! The struggle begins here, as our change-makers try to bridge this gap between them and their students. In the words of Benjamin Franklin, “Tell me and I forget. Teach me and I remember. Involve me and I learn.” Here are a few suggestions for strategies and tools found to help make a seamless transition from the classroom to online teaching and keep learner engagement high through it all!

1. Game-based learning: Sites like www.cellsalive.com and www.turtlediary.com engage students in fun ways of learning. Use of www.pickerwheel.com can create a buzz of excitement by distributing questions and tasks in asynchronous class. Kahoot! is an educational tool that teachers can use in a classroom to pit students against one another in a game setting. Or students can play by themselves to test their knowledge. It appeals to their competitive spirit and enhances experiential learning.

2. Flipped Classroom: In this take on blended learning, students prepare themselves on a given topic individually or in small teams. During the live session, they present their content to their peers and the teacher using a method of their choice within the allotted time. They may also create a short quiz to check the learning of their peers.

(https://cft.vanderbilt.edu/guides-sub-pages/flipping-the-classroom/)

3. Collaborative learning: The brain/mind is social (Caine & Caine, 1991). Collaboration is an important skill to be developed among the new generation learners. Zoom's Break-out Rooms'

feature allows teachers to divide the live class into smaller groups such that students can work together on assigned tasks. Google Docs, Google Sheets, Jamboard are some tools found to be useful in engaging students in collaborative learning tasks during both live and asynchronous classes.

4. Interactive worksheets and video lessons: Google slides with PearDeck and www.nearpod.com allows teachers to create a variety of interactive online presentations which students can work. Teachers could embed videos with questions using www.nearpod.com and www.edpuzzle.com.

5. Padlet: Teachers can use this tool in both synchronous and live classes. Students can answer/pose/questions/put ideas in a text, drawing, photo, video, audio, links etc. Teacher and students can comment on and give a rating to another student's work.

6. Flipgrid: This tool allows students to answer questions/pose questions/ideas orally on video. They could add animations, text, drawing, links etc. as well. Igniting student enthusiasm for learning by making them think, do, discuss and engage in problem-solving is vital for effectively teaching any subject. While tools and techniques to engage classes will continuously change and evolve in the coming years, it is imperative, now more than ever before, that teachers turn into lifelong learners as well.

This is only possible if each one of us makes an honest promise to ourselves to experiment, explore, and engage with new methods as much as we can. After all, we are the ones that the next generation depends!

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FIBONACCI SEQUENCE AND GOLDEN RATIO: TEACHING SCIENCE AND MATHS IN A GARDEN

Manashi Chakraborty and Sakina Gadiwala

Indian Women Scientists' Association, Mumbai

Abstract Field trips to gardens are informal learning opportunities for students where they can have real-life experiences. The Nurtured Garden in Indian Women Scientists' Association (IWSA) campus offers just such an environment. In precovid times, our students experimented with the science of growing, spacing and measuring of plants and plant beds. They also tried out in a fun way, various cooking methods with garden produce, like fermenting, steaming, frying, baking, roasting, pressure-cooking and using microwave oven. Unfortunately, in today's pandemic situation, it is not feasible. In such a scenario, it was incumbent upon the teachers at IWSA to start exploring interesting topics and ways to make online teaching (currently acquiring the new normal status) appealing to the students. One such module was developed by the authors and their colleagues on the concept of Fibonacci Sequence and the famed Golden Ratio, and the examples thereof found in nature. The vast collection of garden photographs, audio and video clips available at IWSA, found useful as online learning tools to introduce these concepts to the students.

Keywords: Fibonacci Sequence, Golden Ratio, Garden Learning

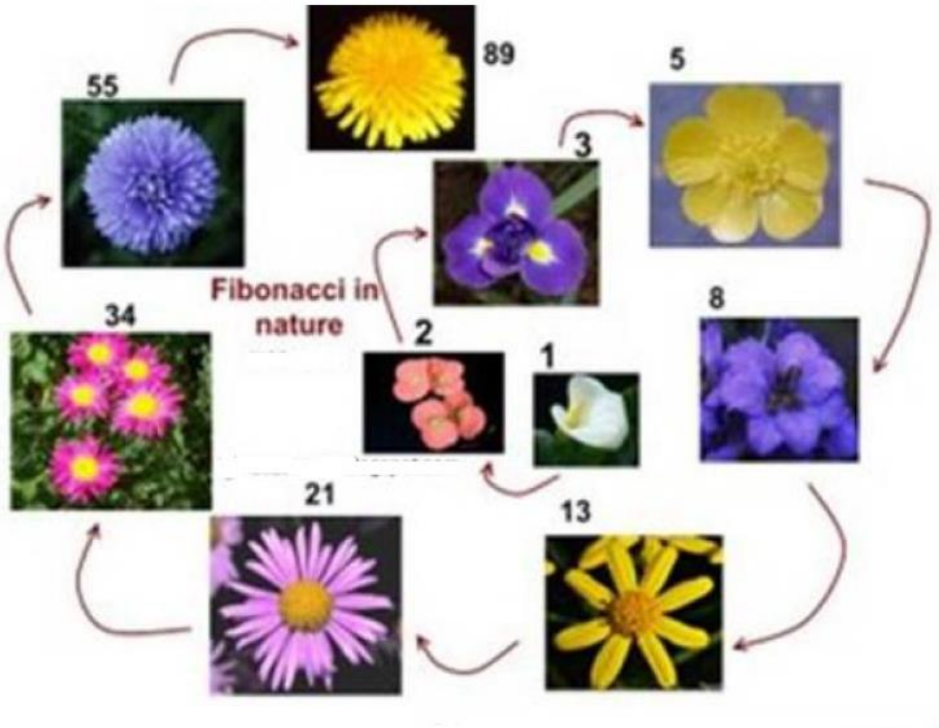
Humans have always been intrigued to see certain patterns in the arrangement of leaves, flower petals in flowers or the branching of a tree. Over time, Greek philosophers, mathematicians, painters and scientists in recent years, have extensively studied these patterns. Experts have worked hard to understand them and use them in different applications but it is only in modern times that we have a better understanding of them through, what is called, Fibonacci Sequence.

Many things in nature follow Fibonacci Sequence. It appears in biological settings, such as branching of trees, phyllotaxis, etc. and its 2 application is not only limited to plants and can be found in other areas also.

It was our attempt at IWSA to teach Maths and Biology in a garden setting in an interdisciplinary way so as to create a joyful learning experience.

Now, let us observe the patterns in plants. The number of petals in some flowers are:

Iris, Lily	Buttercups	Delphiniums	Corn marigold	Aster	Daisies	Sunflower
3	5	8	13	21	34,55,89	89,144



The seed head of poppy seed has 13 ridges on top

The alignment of leaves on the stem of many plants follows a spiral pattern and there, it is seen to be a curious preference for particular numbers and certain spiral geometries that are closely related:

Elm	Cherry	Pear
2	5	8

The spirals formed by individual flowers in the composition of daisies, sunflowers, cauliflowers and broccoli also follow a certain pattern. In a rose bud, the petals are arranged in an elegant spiral shape which helps it to hold maximum number of petals.

Cacti and Succulents, many of them, form similar geometric spirals in their leaf arrangements which help them funnel rain water to the roots and keep upper leaves from shading lower ones.

Phyllotaxis is the study of the arrangement of leaves, branches, flowers or seeds in plants. The rule it follows is not only about the packing of maximum number of leaves, it also helps to maximize Sun Exposure which in turn helps in better photosynthesis. Similarly, in the case of Fruit Sprouts of Pineapple and in the arrangements of Pinecones, Fibonacci Sequence is visible everywhere.

Now, what is Fibonacci Sequence?

Fibonacci Sequence is a series of numbers, where, starting from the third number, every number is the sum of the two preceding numbers.

It can start with either 1 or 0. The sequence will then comprise
1,1,2,3,5,8,13,21,34,55,89,144,...
or 0,1,1,2,3,5,8,13,21,34,55,89,144, ... respectively.

These are the very same numbers we discussed in our observations of nature above. Thus, nature is seen to follow mathematical 4 principles for its survival and growth. The sequence was discovered as a result of a problem posed by the Italian mathematician Leonardo Pisano, called Fibonacci (1170-1240).

Golden Ratio: If we divide a Fibonacci number by the previous Fibonacci number in the sequence, we discover an interesting feature:

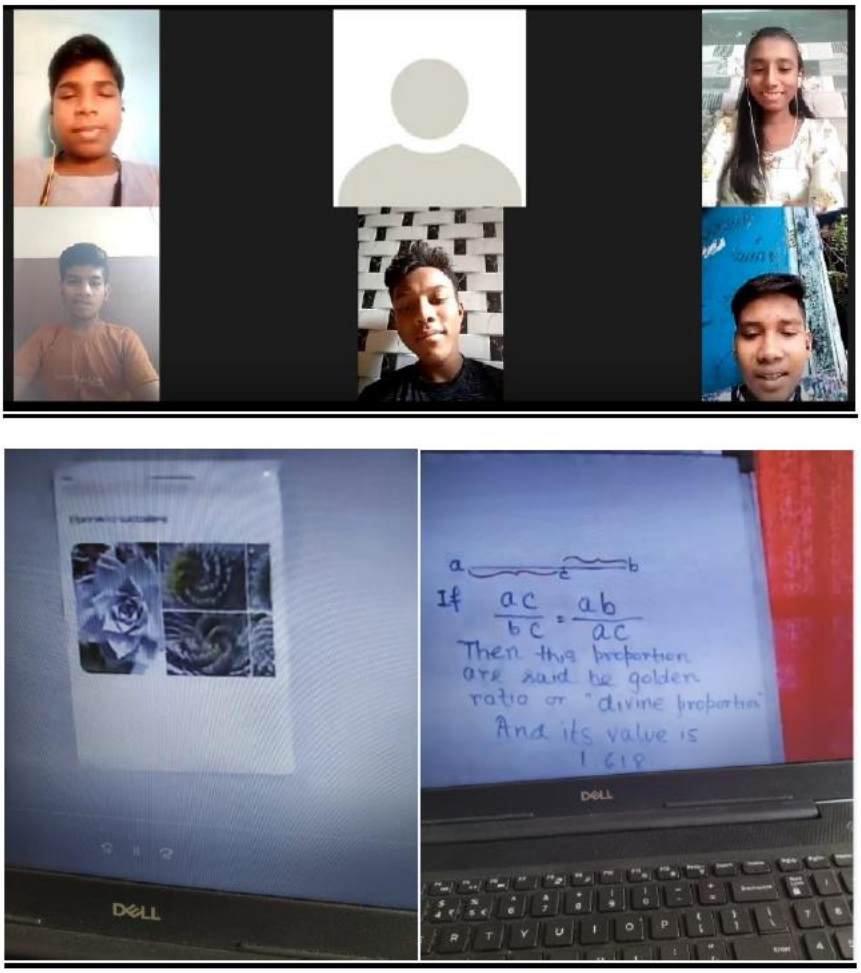
Term of Sequence t	1	2	3	4	5	6	7	8	9	10
Fibonacci number	**0**	**1**	**1**	**2**	**3**	**5**	**8**	**13**	**21**	**34**
Ratio of (t) / (t-1)			*1.000*	*2.000*	*1.500*	*1.667*	*1.600*	*1.625*	*1.615*	*1.619*
Term of Sequence t	11	12	13	14	15	16	17	18	19	20
Fibonacci number	**55**	**89**	**144**	**233**	**377**	**610**	**987**	**1597**	**2584**	**4181**
Ratio of (t) / (t-1)	*1.618*	*1.618*	*1.618*	*1.618*	*.618*	*1.618*	*1.618*	*1.618*	*1.618*	*11.618*

The ratio is seen to tend towards 1.618...
Alternatively, if we divide a segment into two parts such that the longer part, divided by the smaller part, is equal to the whole divided by the longer part, then the resulting ratio is again seen to be 1.618… This is called the Golden Ratio and is denoted by Greek letter phi.(Φ) It is a unique mathematical relation and is used for a variety of applications.

Lucas Numbers and Generalised Fibonacci Sequence: Instead of starting with 0 and 1, Lucas Numbers start with 2 and 1 so as to give the following series:
2, 1, 3, 4, 7, 11, 18, 29, 47, 76, 123, 199, 322, …

Some plants show patterns based not on Fibonacci Numbers but on numbers like 4, 7, 11, 18, … For example, the Fuchsia flower has 4 petals, an uncommon number for petals on a flower. But no matter what numbers one starts with, the ratio of successive terms will always tend to 1.618.., thus giving the generalised Fibonacci series.

An attempt was made to implement online teaching of the aforesaid topic to a test study group with promising feedback of students currently enrolled for the Science Nurture Program at IWSA during the lockdown period.



Students of Science Nurture Program at IWSA attending online class on Fibonacci Sequence and Golden Ratio

Conclusion: Thus, the frequent occurrence of Fibonacci Numbers in nature and the Golden Ratio can be gainfully exploited for its mathematical perfection, aesthetic appeal and biological importance such as in visually pleasing garden designing. Subsequently the Maths Garden can be beneficially extended as a motivational stimulant for arousing curiosity and passion amongst learners to understand the underlying principles and applications of interesting topics beyond customary and conventional classrooms.

Acknowledgement: Dr Param Anthappan and Ms Vijaya Chakravarty (IWSA Members) for guiding in the preparation of the paper.

Developing Online Interactive Environment for Science Teaching and Learning

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The whole educational system from elementary to tertiary level has been collapsed during the lockdown period of the novel Coronavirus disease 2019 (COVID-19) not only in India but across the globe. The digital transformation of education systems in all levels has allowed incorporating a very new teaching–learning system called e-learning. The COVID-19 pandemic caused the closing of classrooms all over the world and forced 1.5 billion students and 63 million educators to suddenly modify their face-to-face academic practices, wherever possible. This situation showed the strengths and weaknesses of education systems facing the challenge of digitalization.

The three pillars of sustainable e-learning are:
(a) Resource Management,
(b) Educational Attainment, and
(c) Professional Development and Innovation.
As education moves to an online environment, some traditional methods of instruction may be jeopardized by lack of immediacy with the instructor and students. Faculty may begin online science education with the idea that if they place their notes online and have a mechanism to exchange problem sets and exams with students that students will learn effectively. Alternatively, a large body of literature describes online learning environments as conducive to different types of learning strategies such as critical thinking, reflection, and active participation and typically rooted in social constructivist learning theories. Social constructivism also is the premise of many of the core principles for science teacher professional development outlined in the national standards and driving research on science teacher professional development. These learning principles promote science teacher professional development that immerses teachers as students within a community of scientific inquiry where they actively investigate phenomena that can be studied scientifically, interpreting results and making sense of findings consistent with currently accepted scientific understanding. They state that these experiences should also incorporate ongoing reflection on the process and outcomes of understanding science through inquiry, and encourage and support teachers in efforts to collaborate.

The nature of communication in online learning environments may be very different than face to face environments, as has been shown in many settings as computer mediated communication (CMC) has replaced face-to-face contact. The lack of social context cues in e-mail in some settings has been shown to lead to uninhibited communication such as hostile and intense language (i.e., flaming), greater selfabsorption, and a resistance to defer speaking turns to higher-status

participants. In other CMC studies, users rated text-based media, including e-mail and computer conferencing, as equally rich or richer than telephone conversations and face-to-face conversations. The asynchronicity of discussion boards is argued to be an important factor in metacognition for learners in online environments. Because a student may take their time to digest a question and formulate a response, and those responses are archived for later viewing, it is believed that this may promote reflection and thus deepen the learning.

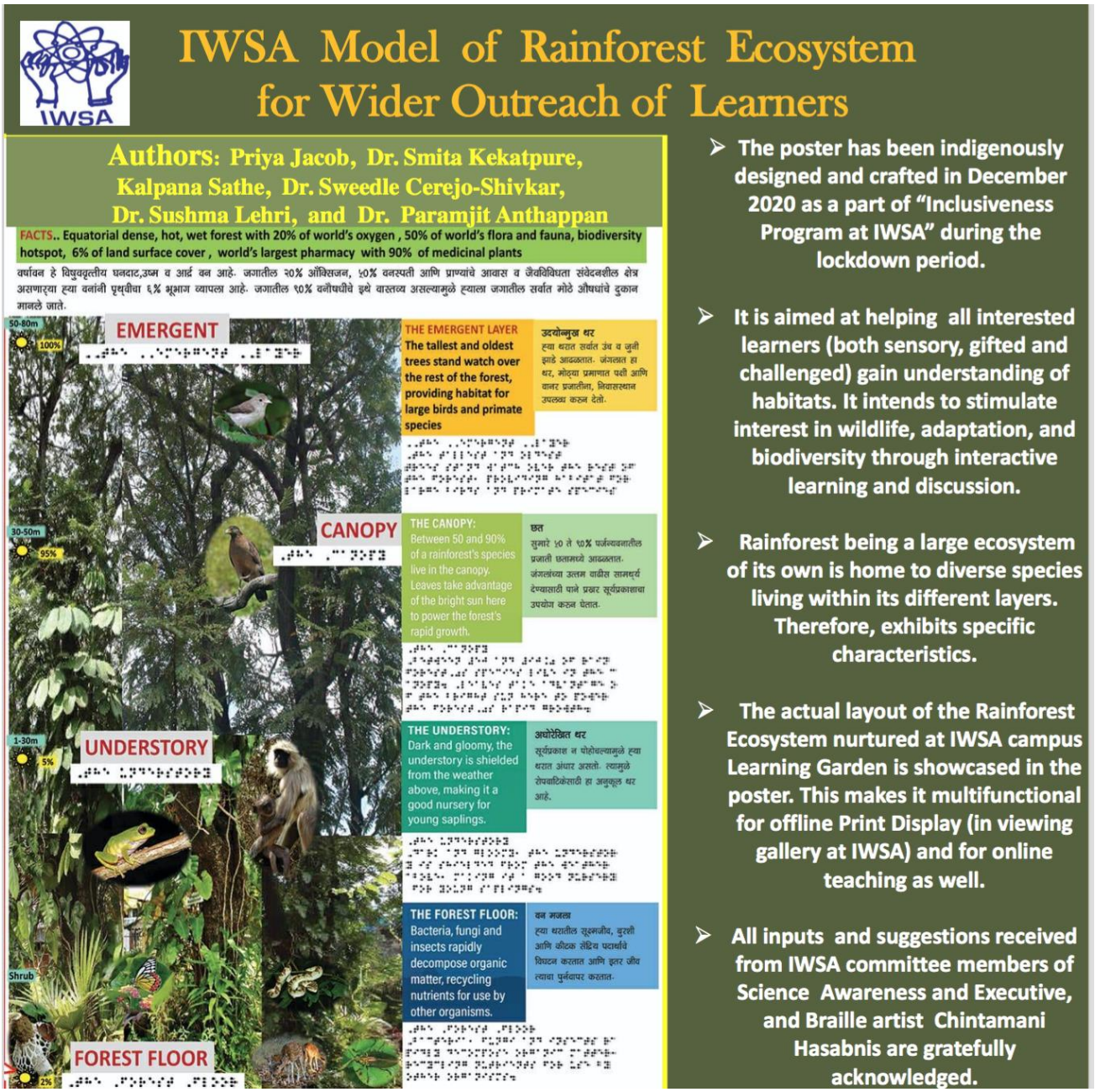
The textual, archivable, and asynchronous properties of online discussion boards provide rich potential for the social construction of knowledge when students take time to articulate their thoughts and questions, gain perspective from the ideas and questions of others, and reflect upon their previous ideas. Students in learning science online courses report participating frequently in mind-on activities such as articulating and reflecting upon scientific ideas. This type of online discussions may promote metacognition and other ways of learning different from what happens in conventional, face-to-face settings. As their use becomes more and more prevalent in the educational community, online discussions and online courses in general merit further research to both examine their effectiveness and also to utilize the new lens they may offer into the learning process, in particular the social construction of knowledge.

The communication in online science courses for teachers is dominated by the use of asynchronous discussion boards. While instructors chose most of the topics for discussion, suggesting that a structure was designed by the instructor for learning as opposed to a purely open-ended conversation, students also reported that most students participated. This begins to portray a vision of a community of learners having possibly found their legitimate roles of participation. The instructor still plays an important role for these students—they see the feedback from their instructor as more useful than feedback from their peers, and they receive their instructors' feedback frequently. The dynamics of communication found in these courses is encouraging and suggests that these environments would be ripe for research on the extent of knowledge construction measurable in these highly social learning communities.

Overall, online science learning environments allow for learning to occur in a setting that is not restricted by place or time. Online learning has the ability to disassemble barriers that have been constructed by poverty, location, disability, as well as other factors. Online science courses offer an excellent way for students to broaden their educational opportunities and stay competitive in the ever demanding realm of education. Communication is notably one of the most crucial elements to an effective online scientific course. Interaction between the learner and the content is the most common type of interaction that occurs in online settings, through lectures and readings. Online science instructors can orchestrate the class environment to increase the interaction between the learner and the instructor and the learner and other learners through both synchronous and asynchronous interactions. There are a multitude of options for students to work collaboratively and cooperatively with other learners and/or the instructor in live debates, reflective journal entries, peer reviews, discussion boards, and video or audio teleconferencing.

Poster Presentations

Poster 1: IWSA Model of Rainforest Ecosystem



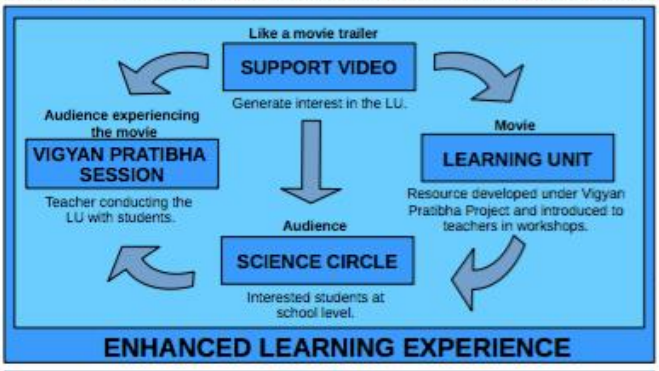
Poster 2: Creation of Supporting Video Resources for Enhanced Learning of Geometric Concepts

Creation of supporting video resources for enhanced learning of geometry concepts.

AmisH Parmar, Sarita Kamat, Pankaj Tadakhe and Deepa Chari
Homi Bhabha Centre for Science Education, TIFR, Mumbai.

What are Learning Units?

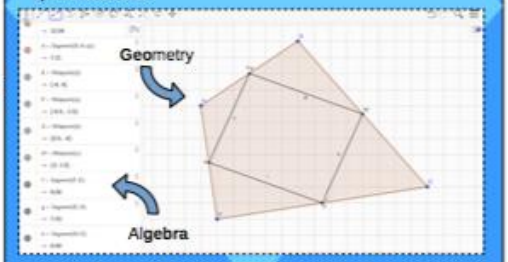
Learning Units (LU) are the core part of Vigyan Pratibha[1] project. They are small learning modules that facilitate exploration. They deal with topics closely related to school curricula, but expose students to dimensions of science and mathematics, that go beyond the textbooks.These will be implemented by school teachers as a part of science circles for interested students. The current work is an attempt to create supporting video materials for these learning units based on mathematics.



ENHANCED LEARNING EXPERIENCE

Midpoint Quadrilaterals[2]

- NCERT Mathematics, Class 8 and 9, Chapters on Quadrilaterals.
- **Midpoint Theorem** for Triangles, here it's **extended to Quadrilaterals**.
- Making **conjectures through observations**, and a geometric approach to proving those conjectures.
- A look at midpoint quadrilaterals of some special quadrilaterals.



Midpoint Quadrilateral drawn in GeoGebra

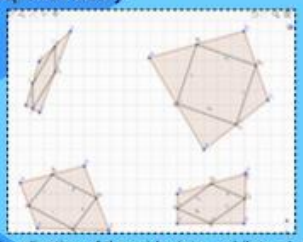
GeoGebra[3]

- Mathematical freeware helpful in understanding co-relation between **Geo**metry and A**lgebra**, as well as other areas of mathematics.
- GeoGebra facilitates drawing large number of quadrilaterals, giving you a **large data set** which is helpful in coming up with **more informed conjectures** from observations.

GeoGebra

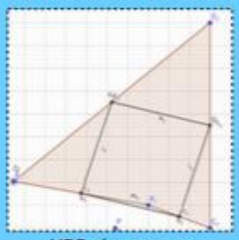
What does the supporting video aim to achieve?

- **Familiarization** - Familiarizes the viewer with the GeoGebra software and its inbuilt tools, as well as the general idea of the Midpoint Quadrilateral Learning Unit.
- **Motivation** - Motivates to explore GeoGebra, and thus the Learning Unit, by asking thought provoking questions.
- **Visualization** - Will help visualize geometrical idea objects and their properties easily.



Visualization of the midpoint quadrilateral of multiple quadrilaterals.

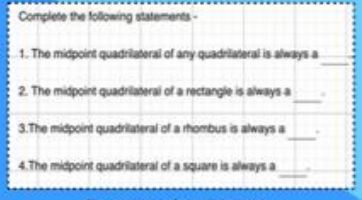
- **Concave Quadrilaterals** - Briefly shows the case of concave quadrilaterals, asserting the fact that the properties of MPQ are not restricted only to convex quadrilaterals which students are more familiar with. Also,challenges students to explore the idea of midpoint quadrilateral of concave quadrilaterals.
- **A Challenge** - Poses an interesting challenge at the end, which aims to test the student's understanding of the applicability of the conjectures on concave quadrilaterals.



MPQ of a concave quadrilateral.

A challenge of finding the MPQ of these concave quadrilaterals.

- **Making Conjectures** - Introduces students to the process of making conjectures, which is an important aspect of mathematics.



Examples of conjectures.

- **Difference in 'Making' & 'Constructing'** - Addresses this subtle, yet important distinction between these 2 ways of creating quadrilaterals, without giving away the answers.

Construction of a Rhombus.

Refrences -
1 - https://vigyanpratibha.in/
2 - https://vigyanpratibha.in/index.php/mid-point-quadrilaterals/
3 - https://www.geogebra.org/classic

Acknowledgements - This work is carried out under Vigyan Prabha Project. We acknowledge the support of the Govt. Of India, Department of Atomic Energy, under the Vigyan Pratibha Project (No. R&D-TFR-0650).
Authors would like to acknowledge the Learning Unit authors and the Vigyan Prabha team, especially Aaloka Kanhere and Ankush Gupta for their continous feedback during the development of this support video.

Poster 3: Transition in pedagogy of science teaching and active learning

Poster 4: Support videos as Supplementary Tool to the Physics Learning Units in online mode

Support videos as supplementary tool to the Physics Learning Units in online mode

Pankaj Tadakhe, AmisH Parmar, Sarita Kamat, Ankush Gupta, Deepa Chari
Homi Bhabha Center for Science Education, TIFR, Mumbai.

About the Learning Units

Learning Units are educational resources designed with an intent to develop enhanced interest, critical thinking, and clear understanding of science and mathematics concepts in high school students under Vigyan Pratibha project. These Learning Units are well within the school curriculum and yet exposes students to dimensions of science and mathematics beyond the realm of textbooks.

Why the need for support videos?

- ❑ Visualize the experimental setup and the intricacies involved in the experiment in Learning Unit.
- ❑ Introduce the viewers to Learning Units through short videos.
- ❑ Encourage the viewers to explore the Learning Units through support videos.

Support videos for Learning Units: Pinhole camera and Experiment on measuring volumes

Pinhole camera

- ❑ A Learning Unit based on pinhole effect, involves students making a simple pinhole camera.

(a) Pinhole camera made with easily available materials.

(b) Transparent bottle and marbles used as alternatives for the experiment.

An experiment on measuring volumes

- ❑ Learning Unit based on students performing an experiment based on the famous childhood fable "Thirsty crow".

Features of the support videos

Design and model making

Emphasizes on the construction of Pinhole camera and the process of model making for the experiment on measuring volumes. Both are crucial steps in the Learning Units.

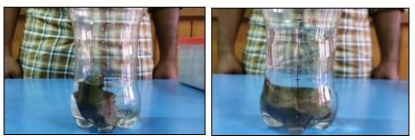
(a) Pinhole camera designed to measure size of large objects.

(b) A model made to perform the "Thirsty crow" experiment

Troubleshooting

Support videos highlight the steps which could introduce error or discrepancy in the construction and the experiment and ways to avoid them.

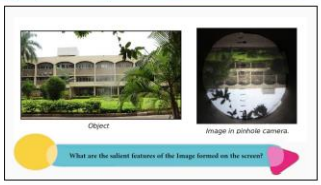
(a) Obstruction in the smooth functioning of the camera.
(b) Steps to fix the problem shown in the video.



(a) Incorrect way to perform the task with the stone partly outside the water.
(b) To start with larger initial amount of water so that the stone is completely submerged.

Cues

The videos contain pop-up questions intended to act as cues to provoke the thought process of the viewer rather than passively watch the video and also generate interest in the topic itself.



Important features of a support video

Support videos are being developed on Learning Units about physics concepts which need deeper understanding. Facts are introduced in an enquiry based approach, that demands critical thinking by the viewers. The videos help direct the viewers to a more detailed discussion on the topic which is in the Unit.

Conclusions and future work

The project plans many such support videos and intends to work on making more of such support videos for Learning Units for different grades. In future these support videos will be disseminated amongst the teachers and students.

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). Authors would like to acknowledge the Learning Unit authors and the Vigyan Pratibha team for their continuous feedback during the development of this support video.

Conference Summary

Since I agreed to summarize the conference, I had to go through it fully without any break which, turned out to be a very pleasant and enlightening experience because of the richness of its content and seriousness of the involvement of the participants.

Dr. A.M. Bhagwat, Chairman Navi Mumbai Science Foundation (NMSF), welcomed the participants and introduced functions of NMSF. He described how the teachers are in a position now to update their technological skills in order to cope with the online classes and this conference is just the right platform for share the ideas to enhance their performance. He then introduced the honourable chief guest Dr. A.P. Deshpande and invited him to deliver his lecture. Dr. Deshpande in a positive note mentioned that the downward trend of our life will turn around and start moving upwards just like a sinusoidal oscillation and this pandemic will end and our lives will improve. He also traced the history of online method of education which dated back to the time when All India Radio and Doordarshan conducted educational programs for University curriculum. This legacy of online classes was aimed at a wider audience without too much cost. In the present scenario, he mentioned that, we have new technology and the devices have improved but the methods of online education are available to us from those days.

Prof. Chitra Natarajan Memorial Lecture was delivered by Dr. Shweta Naik, Homi Bhabha Centre for Science Education. She centred her lecture around a question, "What is this thing called science?", and explained the scientific attitude and knowledge in the ambit of human life, society, authority, personal experience and rationalism. The scientific mentality, method, and even the four-stage method of scientific process are under question after four or five hundred years of their existence. Scientific process is something that takes you closer to the truth. In this talk what attracted me most is the description of how scientific knowledge as an object or as a concept sits with the society. While for the scientifically educated it goes as explanations and empiricism etc, for the rest of the society it is authority and popularity. For the general public, words of authority or what is popular may appeal more than the wise words of a learned scientists. Our teaching methods should improve to the extent to make students distinguish between science and pseudoscience and let them take decisions not based on feelings but on reasoning – an opinion which was also echoed by another invited speaker, Rohini Karandikar.

Following this event, Ms. Sangeeta Sohni, the winner of president award for teachers from Atomic energy central school was felicitated. The list of Vikram Sarabhai essay cum elocution competition winners were also displayed.

Invited speakers did an excellent job of defining the problems and attempting to solve them. The problems can be posed as
1. Is online education complete? 2. Is online education effective and 3. Should we continue only with online education? The solutions came in different forms, what online can do now, in which way online education can harm, which way the online education can supplement and which way a paradigm shift in methods of online education can influence the future. Kishore Darak had a fairly complete list of problems that are posed by online education covering educational, technological as well as societal points of view.

Obviously, none of us are happy with only online education. We all want to go back to class rooms and have human interactions. One of the most important disadvantages is that there is no interaction with the students, there is no monitoring of the students. Various methods were suggested to improve teacher student interaction. Several example scenarios of successful interactions were presented where regular classes could be conducted with the involvement of the students while they are monitored and evaluated. The peer interaction however can not be brought in the online classes. Pushpinder Bhatia's talk explained the global efforts in making the online classes involving UNESCO and their 9-point agenda to reduce the digital divide and bring those who are affected by it to the right side of the divide. She indicated the possible enormity of a global university – possibly run by google and conducted by MIT.

The advantages of online education. Almost everyone who talked agreed that, because the online classes are recorded and hence could be a better method for teaching theory. The students could go back and hear the lessons again and again. An important method was shown by Gautam Karve in the form of explanation map which gives the students not only the concept but also the making of the concept. Since the students are making the map themselves online, they get to have a feeling of belonging to the concepts. While the theory could be better-off taught online, the practical education takes a beating. A good example was presented by teachers from IWSA where there was a garden as a classroom and the biological processes as they happen could directly be shown to the students. Biology practical education to a large extent however could be covered using video recording under the conditions where the dissections etc are anyway banned in the classrooms. The biggest hit comes to chemistry. Mainly because chemicals are dangerous for young students. It is not prudent to put the chemicals in the hands of inexperienced students and hence a contact class is a must. There were demonstrations using harmless and inexpensive chemicals normally available at home used for teaching chemistry experiments like acid base

titration etc. Other important things that are missed in the video education is 1. the timing involved in doing the experiment and 2. the students' perspective of observing the real experiment which is almost always hindered or engineered by videography. The virtual laboratories like olabs give the students an experience of carrying out the experiments on a simulated platform, however these platforms do not allow the students to make mistakes. Where as a lot is learnt in the laboratory through trial and error. Probably these simulations must include possibility of making mistakes so that the students will get a chance to make mistake and correct them.

With children being savvier with the new devices, they have more access which may expose them to undesirable environment. On a positive note, such experiences will help them live with instruments which will become common in the future.

I hope I have done justice to the very rich content of today's conference and thank you very much for patiently listening to me at the end of this very long day.

-A.K. Rajarajan