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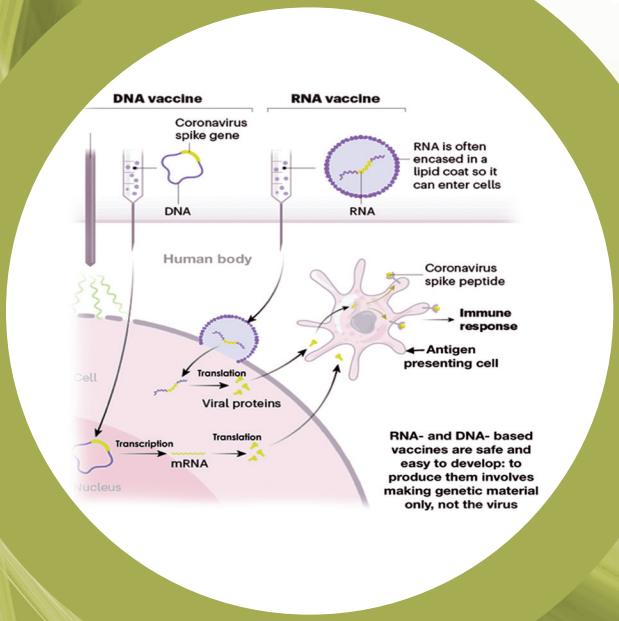

Inducing immunity by Nucleic and Vaccines: Spearhead Candidates for COVID-19. [Ewen Calaway, 2021]

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About the Journal

School Science is a peer-reviewed journal published quarterly by the National Council of Educa tional Research and Training, New Delhi. It aims to bring within easy reach of teachers and students the recent developments in the areas of science, mathematics, and environment by serving as a platform to disseminate research findings, sharing innovative pedagogies, theoretical work and other advances towards improving teaching-learning in such areas.

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EDITORIAL

In this second part of the special issue on COVID-19 and the Environment, we have included articles related to SARS-CoV-2 and COVID-19 covering various aspects such as prophylactic measures, digital literacy, online teaching-learning, awareness and immune system and vaccines.

As we are aware, COVID-19 brought about a sudden change in the mode of teaching-learning as online or virtual learning was resorted to. Much have been said about the downside of such mode of learning. However, in the article 'Re-imagining science education during COVID-19 pandemic: Role of teachers, students and parents,' the authors discuss how virtual learning environments provide broad scope for inquiry-based, investigative, and interactive science learning through systematic and equitable collaboration between teachers, students and parents using and illustration.

The article 'Plant-based dietary items with prophylactic and therapeutic action against novel Coronavirus' reviews the possibility of some food and drinks items whose bioactive molecules could serve as physiological masks against novel Coronavirus and its variants.

'People's awareness on Coronavirus disease (COVID-19) in the context of its transmission and epidemiology — A study' and 'Role of scientific literacy in eradicating superstitious beliefs during ongoing COVID-19 pandemic' discuss a common person's knowledge of COVID-19 symptoms, transmission and the relation between education and awareness.

'Deliberating on environmental education and its practices during the COVID-19 pandemic' provokes the epistemological debate that exists in the field of environmental education in the context of the present pandemic situation.

This pandemic has almost rewritten teachers' job requirements, redefining the roles and responsibilities of educators once and for all. Along these lines, the articles: 'Science teaching-learning in the online mode: A study of techno-pedagogical knowledge development in teachers', 'Digital literacy as a challenge for students to attend online classes during COVID-19 pandemic: A critical analysis', and 'Online science teaching and learning among children during COVID-19 pandemic' bring out varied aspects of digitisation in teaching-learning in the wake of the COVID-19 pandemic.

Part-I of the article 'An introduction to immune system with special focus on vaccines for SARS-CoV-2' provides a broad idea of the various aspects of the immune system, such as what pathogens do to our body and how our immune system is working. Part II of this article deals with vaccines, vaccine design, how vaccines are developed and how they provide immunity to specific diseases, especially in the context of the coronavirus, SARS-CoV-2.

In addition to the articles, this issue also contains interesting findings and developments in different areas of science that are covered in Science News.

As always, we welcome your valuable suggestions. Happy reading and happy learning!

RE-IMAGINING SCIENCE EDUCATION DURING COVID-19 PANDEMIC: ROLE OF TEACHERS, STUDENTS AND PARENTS

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The COVID-19 pandemic necessitates educators and teachers to think about novel teaching-learning methods, which enable deeper understanding and active involvement of students in their learning process. Given the nature of science, it is essential to design and create learning experiences that promote inquiry-based learning at home, nurture curiosity, and encourage learners to develop scientific understanding through reflection. There is a fear that virtual learning environments, both synchronous or asynchronous, can open doors for a more passive, lecture-based science pedagogy due to the unavailability of resources and support at home for most children in India. This paper re-envisions and outlines the roles that different stakeholders can play in creating a nurturing environment for science education at home through a short activity plan. This disquisition argues that virtual learning environments offer a broad scope for inquiry-based, investigative, and interactive science learning through systematic and equitable collaboration between teachers, students, and parents.

Keywords: Virtual teaching, digital technology, parental involvement in science education, learning activity, COVID-19.

Introduction

The COVID-19 pandemic has forced school closures for extended periods throughout India. As students move into the new academic year while being based out of their homes, teachers and parents explore newer ways of supporting students' science learning. School-based and home-based environments are inherently different and shape different aspects of students' learning. Learning goals and lessons cannot simply be transposed from schools to homes, as parents/families cannot act as teachers, and students do not experience the same environment at home in terms of access to peers, materials, routines and norms, and other educators/professionals. Thus, science learning experiences need to be designed, keeping unique aspects of home-based environments in mind such that these experiences lead to complementary and meaningful science learning. These experiences need to support students' social, emotional, and mental health and allow for an exploration of the real-world and context-specific relevant science. This paper aims to layout various ways, through a short activity plan, via which different stakeholders can support students' science learning during and after the pandemic.

The National Curriculum Framework (2005) and the National Focus Group on Teaching of Science (2006) present the goals for student science learning regardless of learning location. These documents also elaborate on the key features of science lessons and activities and how different learning

environments enable student learning in different ways. The effectiveness of any learning experience depends on its ability to achieve culturally relevant learning goals and whether the different approaches employed to achieve these goals are contextually sensible. This is true for learning experiences designed both for classrooms and homes and for both online and offline modes. Learning goals typically neglected in the classrooms can be achieved in home-based learning environments. For instance, learning experiences that help students and their families address problems and phenomena around them may be valuable for the entire community.

Home-based learning is most successful when teachers, students, and families work together in complementary and collaborative ways. Science lessons and activities that allow students' interactions with family and community members promote a deeper understanding of science as they are situated in meaningful and flexible learning contexts. Apart from gaining from the unique expertise of the community members, such experiences provide exposure to authentic problems and contextual phenomena for students to think, explore and engage with. When students engage with relevant issues in meaningful ways, they develop an interest in the topic at hand and pursue it playfully. However, for home-based science learning to be successful, teachers, students, and parents/families need to play an active role in operationalising such learning experiences. The next section of the paper elaborates on teachers', students' and families' role in supporting meaningful home-based science learning of students.

Role of Teachers, Students and Parents

Teachers

Teachers play the most crucial role in the design and implementation of equitable, coherent, and meaningful science learning experiences that ensure students learn beyond the physical boundaries of the classroom. Therefore, it is important that teachers move away from the lecture-method and the excessive focus on content coverage and instead, create, select, and adapt instructional materials, lessons and experiences for home-based environments such that they are relevant and engaging for all students.

As instructional and pedagogical experts and teachers know best about their students, their progress and how they can be appropriately supported to achieve the desired learning objectives and goals. However, as students are based out of homes for extended periods, teachers should not waste valuable instructional time on lessons with minimal relevance to students' context and the problems and phenomena that their families and communities face. Rather, teachers should design and plan learning experiences through experiments, projects and investigations that can be carried out relatively easily through locally available materials, for which they can take the help of their parents and families if required.

Though students may come from similar contexts, they may have starkly different home environments, and hence, it is important that teachers design lessons, experiments and projects that students

can pursue flexibly, asynchronously and in different home environments. While it may initially seem difficult, teachers also need to provide students with opportunities to connect their science learning with their interests by providing them with choices for projects and assignments such that they can make sense of the lessons and the concept(s). This needs to be done keeping in mind the curriculum progression, coherence and leveraging the affordances that modern technology has to offer. Given that the pandemic situation is rapidly changing and unfolds as time progresses, it is imperative that students are invited to contribute and direct their learning through the mutual design of instructional experiences. Last but not the least, teachers need to provide appropriate and regular feedback to the students and establish mechanisms that guide and enhance students' scientific thinking.

Students

Students need to be actively engaged in the learning experiences rather than trying to memorise and retain information. They should explore problems and phenomena that interest them and matter to their communities. Instead of learning solely and further isolating themselves, students need to engage with their peers regularly to advance their own and others' learning. By working both independently and collaboratively on different assignments and projects, multiple possibilities and perspectives emerge. Moreover, students need to actively reflect on their own learning — what they are learning and how they are learning it. Such reflection on experiments and activities helps one consolidate their learning and gives rise to new questions. As discussed, students need to play an active role in contributing and directing their own learning through the mutual design of instructional experiences with their teachers and peers. Lastly, it is crucial that students regularly document, via pictures, text, videos or audios, what they have done, learnt, or are thinking about. This documentation can then be shared with peers, teachers and family members to receive comments and feedback, which enriches learning.

Parents and Families

The first and foremost role of parents and families is to support students' emotional and mental health needs. Then, based on their experiences, parents should discuss with their children the problems and phenomena that exist in their communities and are context-specific. Despite the challenges families and communities face due to the circumstances exacerbated by the COVID-19 pandemic and the resulting lockdown, parents/families need to act as co-learners with their children and provide the partnership that students expect from adults. Parents can offer valuable insights by sharing their expertise and varied perspectives on these problems and phenomena that affect their lives. While it is difficult for parents to mimic school-based lessons and learning experiences at home, they can act as thought-partners with teachers and supplement the science lessons with the community and home-based learning experiences that connect with and develop students' interests.

Parents and family members can play multiple roles in enhancing students' learning of science. They can encourage students by providing positive feedback and support on their work. They can act as sounding boards

and provide constructive feedback on a project or investigation/experiment that students have been involved in. They can also help children to find and source locally-available resources and materials required for conducting experiments. Moreover, they can act as co-learners and collaboratively work with students on investigations, helping them to reflect and visualise their learning from the task at hand. Parents and families can talk to their children and discuss their interests and pursue them in the current scenario. They can work with the teachers helping them design lessons and activities based on this understanding of students' interests.

Additionally, parents can help students' science learning by organising peer-group learning sessions by collaborating with other parents and families. Furthermore, parents and families can help their children contextualise certain concepts and topics by providing practical examples from varied situations or their own experiences. They can communicate and discuss their knowledge and understanding of a topic or idea with students, helping them figure out the phenomena from different perspectives. Lastly, given their socio-economic standing, parents and families can provide students with follow-up learning opportunities that build upon their existing knowledge, interests and curiosities.

The next section discusses a virtual activity plan on the pressure exerted by fluids for Class VIII students. This session has been designed for both asynchronous and synchronous modes and demonstrates the role of teachers, students, parents and families. The activity plan is designed to involve different stakeholders in the process of students' learning science and how in their different capacities, they can ensure that students get an opportunity to engage in scientific enquiry through hands-on experimentation via these virtual sessions. The session also provides students time and space for formulating their own understanding and idea about the concept through reflections on the work they engage in.

Activity Plan

Objective of the lesson

By the end of the session, students will be able to:

1. observe and report that liquids exert pressure,
2. demonstrate that water comes out at different speeds from the openings punctured in a bottle at different heights,
3. demonstrate that pressure does not depend on the shape of the container but the height at which the hole is punctured, and
4. analyse why liquid gushes out at different speeds from the openings in the bottle at different heights.

Assessment Task

1. Observations and Reporting
   - Review the observations and reflection shared by the students
2. Check for Understanding
   - Can liquids exert pressure? Give reasons for your answer.
   - Have you seen water towers and

overhead water tanks? Why do you think water towers are located at a greater height from the ground? Discuss with your friends, family and classmates and write a short explanation for the same.

Sequence of Activity

(a) Asynchronous Session

In an asynchronous session, students engage with recorded lesson videos sent by the teacher. Let us now look at the role of each stakeholder in the given activity plan.

Teacher	Students	Parents/Families
Part 1		
The teacher sends the first video of the session, asking the students to pause and recall the concepts covered in the last session. After a short pause, the video displays a mind map of the previous session's ideas. Students had covered the concept of 'pressure' in their last session.	Students revisit the last session's topics by looking at their notes or making a mind map. Students then proceed to look at the mind map given in the video.	Parents are encouraged to ensure that students pause, reflect, and only then look at the mind map given in the video.
Part 2		
The next section of the video sent by the teacher has a prompt for discussion. Students discuss the question: Can liquids exert pressure? Why do you think so? A short explanation of the answer can be sent by students via Google Forms. After receiving the responses, the teacher can send the next video to the learners.	Students discuss this prompt with their parents/family members/guardians/ friends and fill the Google Form.	Parents ensure that the student discusses and writes the answer. They can provide their own understanding of the topic based on their experiences. The Google Form link can be accessed on their devices for students to send their observations to the teacher.

Part 3		
At this point, the teacher shares the second video of the session, provided the response to the first activity is received. Teacher will not yet reveal the answer to the questions they have discussed. This second video consists of instructions to perform two experiments. A short note on how to supervise this experiment should be shared with the parents a week prior. **Experiment 1** Make two holes in a bottle at different heights and seal the holes with cello tape. Fill the bottle with water, remove the tape and let the water pour out. What did you observe?	Students perform the two experiments under the guidance of their parents and report their observations via the Google Form.	Parents are requested to organise and supervise the two experiments. The short note consists of a video of the two experiments, which can help them guide the process. The Google Form link can be accessed on their devices for students to send their observations.
Experiment 2 Take two or three containers. Make a hole in each container at the same height. You can use a ruler. Seal the holes with cello tape. Fill the containers with water, remove the tape and let the water flow out. What did you observe here? Anything different from Experiment 1? Teacher asks students to send their observations through Google Form.		

Part 4		
Teacher shares the next video with the learner, wherein (s)he shares observations on the experiments. In this video, (s)he asks them to reflect on the following questions and send their answers through another Google Form. -Do these experiments prove water exerts pressure? How? - In the first experiment, why did the water come out at different speeds from holes at different heights? - In the second experiment, why did the water come out at the same speed from containers of different sizes?	Students reflect on these questions. They are free to discuss them with their family or classmates before sending their answers to the teacher.	The Google Form link can be accessed on their devices for students to send their reasons and analysis of the observations.
Part 5		
After receiving students' analysis, the teacher sends the final video consolidating their analysis and explaining the concept of pressure exerted by liquids. Students read the textbook portion on the topic and complete an assessment task used by the teacher to check their understanding.	Students watch the video to understand the concept, read the textbook portion, and attempt the assessment task and send it to the teacher. (Assessment task has been described at the beginning of the activity plan)	Parents should ensure that students send in their assessment tasks.

This asynchronous session can be supplemented with a short debrief online session based on the evaluation of students' responses received on the assessment task.

(b) Synchronous Session

For a synchronous session over Zoom or any other similar platform, the teacher will conduct each part with support and help from the parents during experiments and activities. Parents' role decreases as teacher-led discussions can be conducted within the online platform via chat/breakout rooms. The teacher can help students conduct the experiment through live instructions/ demonstration while resolving queries simultaneously. The pauses for reflection in an online class can be easily achieved without Google Form submissions. Teachers can record the session and copy-paste the chat to later formatively assess the responses received by each student and plan the next session accordingly. Though the role of the parents/family members substantially

reduces in a synchronous session, it is still required to help students conduct activities and experiments using locally-available resources.

Conclusion

The nature of the activity plan discussed above is different from how a typical lesson is designed and implemented in a regular classroom. Teachers need to design virtual sessions differently to ascertain maximal student engagement. The asynchronous version above is divided into parts, and completion of activity in each part takes the students to the next level. Providing the entire video lesson at once will eliminate any scope for reflection or analysis, and students will rely on the teacher's explanation of the concept. While the activities designed require some technological prerequisites, this activity plan can be implemented in a resource-constrained environment with limited connectivity through the asynchronous mode. It makes use of locally available materials and there by not letting sophisticated or expensive equipment(s) cause a roadblock in learning the concept at hand. This activity plan also takes into account the nature of parental involvement in the session. The involvement outlined is minimal and supportive and encourages parents to engage in a scientific reflective dialogue through means of experiments designed. Such conversations can be achieved if science is connected to the students' daily life experiences and their communities. Family members and friends have an intuitive understanding of different phenomena and processes, which can help students derive scientific applications and explanations. In this activity plan, the assessment task is based on a simple concept of placing a water tower at a height or construction of a tall water tower to create adequate pressure so that water can easily reach the houses. This collaboration between teachers and parents can be strengthened by teachers taking the initiative and proactively communicating with students' families regarding their role and support. While some guidance and encouragement will be required initially to involve parents in the process, this can potentially evolve into a long-term association aimed towards creating a supportive, scientific environment for the students beyond the physical classroom.

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PLANT-BASED DIETARY ITEMS WITH PROPHYLACTIC AND THERAPEUTIC ACTION AGAINST NOVEL CORONAVIRUS

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The ever-flourishing human survival and dominance during the current Anthropocene era in the earth's history has seemingly been punctuated by the deaths of millions of human beings on account of the COVID-19 calamity. Within a year of the onset of the pandemic, humanity has proved its biotechnological might of the twenty-first century through developing many safe and efficacious vaccines by exemplary global co-ordination and ethical collaboration. We now aptly learned how a minuscule virus SARS-CoV-2 quite insidiously reached every nook and corner of the globe and resulted in an unprecedented loss and devastation of global economic activities. Curiously, the COVID-19 pandemic has raised several puzzling questions of life science. Among others, the most crucial question that intrigued scientists, why did a new strain of Coronavirus emerge with ten times greater infectivity than its predecessors? The enigmatic intra-molecular maneuvers in virus structure further ensured the evolution of many more variants with much greater infectivity. Despite the availability of efficacious vaccines, the absence of potent curative medicines and the evolution of escape mutations are the most important reasons for the future possibility of recurrence of the virus. So, predictive pandemic monitoring preparedness must be in place to contain epidemics or pandemics through herbal immune boosters, non-pharmaceutical measures and conservation of biodiversity as per the concept of planetary health. Alleviation of disease symptoms through dietary modification and supplementation has been an age-old practice. To date, many bioactive compounds of plant origin with immense prophylactic and therapeutic potential have been selected as biomedicines. The present article reviews the possibility of some food and drink items whose bioactive molecules could serve as physiological masks against novel Coronavirus and variants. Sprouts of peanuts, soybean, grapes, licorice, turmeric, black cumin, black pepper, snake gourd, cloves, cinnamon, citrus fruits, tea, neem, *shatavari,* and *ashwagandha* have been selected as anti-SARS-CoV-2 food and beverage items based on preclinical pharmacological screening studies. Since food items described above have been traditionally used, there is no doubt of their adverse side effects or toxicity.

Keywords: SARS-CoV-2, pandemic, infectious disease, COVID-19, evolution, planetary health, biodiversity, healthcare, medicine, ecology.

Introduction

The COVID-19 pandemic is an ecological consequence of biodiversity loss on account of endangerment and extinction of species. In nature's law, such stressors often serve as an essential prerequisite for the evolution of new infectious agents with life-threatening capabilities through mutations and re-combinations. The world recently eye-witnessed an unprecedented loss and devastation of the global economy and human life on account of COVID-19, unparalleled in human history. Owing to scientific advancements in aviation technologies, information communication technology, roads and waterways transportation technologies, the world has now shrunk into a global village. The global human population can travel to their planetary destinations at much ease and comfort, searching for livelihood. However, the menace of the spread of infectious diseases is also growing at a similar pace.

We aptly learned how a minuscule virus, SARS-CoV-2 originated at Wuhan city of China, spread to every nook and corner of the world within a short time like a forest fire! According to some scientific estimates, globally more than 300 infectious diseases have emerged among humans during 1940 and 2004 and concomitantly infectious diseases also appeared in wildlife, domesticated animals, wild plants and crop species (Jones et al., 2008). It is estimated that about 60-80 per cent of humans' infectious diseases are of zoonotic origin, i.e., infectious agents transferred from animals to humans. The underlying causes of such emergence are believed to be based on changes in land use, agricultural or other food production practices, or wildlife hunting, increasing rates of contact or encounters between humans and animals. The Nipah virus, SARS-CoV, MERS CoV, and current SARS-CoV-2 are prominent examples of zoonotic virus originated through spillover from wild bats. It is believed that half of the zoonotic diseases that have emerged in humans since 1940 are on account of human activities, while about 20 per cent are through the evolution of drug resistance (Keesing et al., 2010). The world's ecologists and medical scientists have reached a consensus that human activities increasingly play active roles in the emergence of deadly infectious diseases. Therefore, all the consequences like lockdown, the shutdown of the global economy, unprecedented human sufferings and death toll on account of the COVID-19 pandemic have been brought about by human beings themselves, unfortunately, being oblivious to the harsh realities of nature and its philosophy. It reminds us of the famous quote by a French writer, Jean Bruller, "All of humanity's troubles are because we do not know what we are and cannot agree on what to become."

In consideration of our biosphere's extremely fragile ecological state, the Rockefeller Foundation, in collaboration with Lancet Commission, recently propounded the idea of planetary health in 2015 to highlight increasing threats of deadly infectious diseases for human health and well-being at a global scale (Horton, 2015). This emphatically states planetary health to be the health of human civilization and the state of the natural systems. It depends and calls for international collaborations and concerted exceptional actions for an outright check on jumps or spillover of viruses and other infectious microorganisms at the source itself. Such exceptional actions by protecting global biodiversity and scrupulously addressing climate change issues by human beings would save billions of dollars on frequent vaccine discoveries and production. Above all, great havoc and panic of pandemics would also be curtailed. As per the World Health Organization report, in January 2021, there have been 102 million confirmed cases of COVID-19 and 2.2 million deaths on record. While in India, the infection tally touched 10.7 million with 1.5 lakh deaths even after a complete lockdown of economic activities for about three months and restricted activities. During September 2020, the pandemic situation in India was the worst, with an infection rate as high as 100,000 cases and deaths of more than 1000 per day. As of February 2021, the daily infection and death rate declined to 10000-13000 and 127, respectively. Nevertheless, the world is curiously waiting for some effective targeted medicines yet to be discovered. The global hunt for potent therapeutics, effective

vaccines and vaccine administration against SARS-CoV-2 are the new buzzwords of all government's agenda and daily news and analysis in global media. The Government of India in its union budget for 2021-22 has allocated Rs. 350000 million for vaccination programmes.

Recalling the last ten months of unusual situations has been frightening and terrifying for all of us. Reports on discriminative and partisan behavior on the part of hospital administration, cynicism among medical professionals, particularly during the pandemic, were social stigmas. Therefore, society must value and appreciate healthcare professionals' efforts as Corona warriors and healthcare professionals must also adhere to the bioethics of medical profession (Narayan, 2006). Despite the world's largest vaccination program currently undertaken against COVID-19, lack of specific medicine and fear of immunity evading variants are important reasons for the pandemic's recurrence shortly. Vital know-how and true education on ways and means to provide relief from the anticipated crisis caused by Damocles sword of COVID-19 would be the need of the hour. Consistent with the views described above, the article aims at educating readers on some scientifically and pharmacologically studied anti-SARS-CoV-2 plant-based dietary foodstuff, non-alcoholic beverages and herbs commonly available in our vicinity as functional food medicines. It has two-pronged actions, preventive and curative, in case of infections through a broad range of variants of COVID-19. Introduction of SARS-CoV-2 with the mode of transmission, pathogenesis, mortality and current medicines along with dietary therapy have been briefly presented in subsequent paragraphs of the article. Although modern pharmaceutical technologies have greatly supported the identification and isolation of plant-based bioactive compounds of prophylactic and therapeutic values against viral diseases, their accessibility to common people is highly restricted due to expensive extraction processes from live plants. Routine production of nutraceuticals such as quercetin, resveratrol, flavonoids and alkaloids could be undertaken at an industrial scale through *in vitro* culture technologies (Narayan, 2015; Narayan, 2016).

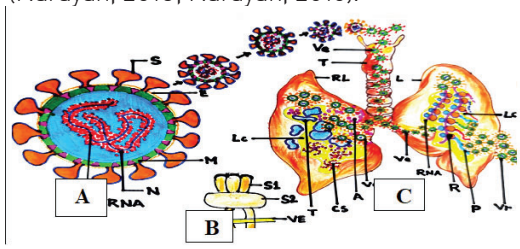

Fig. 1 (A). Diagrammatic representation of SARS-CoV-2 structure and pathogenicity in human lungs; A. Structure of SARS-CoV-2 (S-spike, E-envelope, M-membrane, N-nucleoprotein, RNA) B. Structure of spike (S1 & S2-receptor binding proteins; VE-virus envelope) C. Structure of human lungs, mode of viral invasion, and host-pathogen interaction (Ve- viral invasion, T-trachea, RL-right lung, Lc-lung cell, T-killer T-cells, CS-cytokine storms, A-anti-bodies, L-left lung, RNA, R-ribosomes, P-proteins, Vr-newly formed virus particles

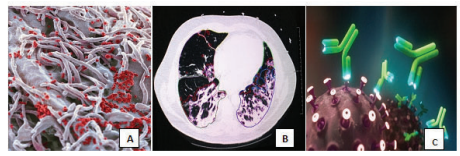

Fig. 1 (B). Infection, pathogenesis and control of COVID-19; A. Human cell studded with SARS-CoV-2 particles red in color (Credit: Dr Katherine Davies, National Infection Service/SPL/nature) B. Scanned image of lung damaged through COVID-19 (Credit: Nathan Laine/ Bloomberg/ Getty/ nature) C. Artist's conceptualization on monoclonal antibodies binding with spikes of coronavirus (Credit: Sci-comm Studio/ Science photo library/ nature)

Morbidities, mortalities, and medical interventions for combating COVID-19

Although there are some rapid test methods to confirm infection through SARS-CoV-2, such as rapid antigen or antibody tests, real-time PCR is the most accurate confirmatory diagnosis method, detecting viral genome in nasal, throat swabs or blood samples. The incubation period of the virus is reported to be between 1 to 14 days; however, much-enhanced infectivity of SARS-CoV-2 compared to SARS-CoV and MERS CoV is attributed to the transmission through asymptomatic as well as pre-symptomatic carriers. This type of transmission within healthy individuals constitutes a large proportion (of about 80) of infected persons. Moreover, SARS-CoV-2 could also be transmitted during the latency period. These are the reasons why COVID-19 is spreading like wildfire. The case fatality rate of COVID-19 worldwide is around 3-5 per cent so far; however, it may go much higher in elderly persons, co-morbidity conditions and among people who are immunosuppressioned reported to be at 14.8 per cent (Taghizadeh-Hesary and Akbari, 2020). Some common symptoms of COVID-19 include a flu-like illness with fever, sore throat, cough, fatigue, dyspnoea. However, in select groups of people, elderly or co-morbid patients, disease progression aggravates as acute respiratory distress syndrome (ARDS), septic shock and multi-organ failure, finally leading to mortality. Currently, symptomatic healthcare facility is being provided to patients since no specific anti-viral medicines are in place. Milder symptoms occur because of the presence of viral antigens in the host and proportionate defensive immune reaction or response by the host; thereby, cellular and humoral or innate immunity produces viral-specific T-cells (CD4+, CD8+) and virus-specific antibodies. Hence, patients with milder symptoms are being treated with those medicines that block viral entry to host cells, also block replication to alleviate symptoms and reduce infectivity. Thereby, the viral transmission is curtailed. Severe cases of COVID-19 are characterised by ARDS responsible for health deterioration and mortality of patients. ARDS is caused by cytokine releasing syndrome, which occurs when the host immune system hyperactively responds to the viral genome inside cells. The hyperactive response involves large-scale production and release of pro-inflammatory cytokines such as IL-6, IL-1, etc., and chemokines and their vigorous circulation in the cytoplasm of cells (Fig. 1 A). Such conditions cause damage to vascular endothelium and parenchyma cells of lung tissues (Fig. 1B). Consequently, patients with damaged swollen lungs often encounter breathing difficulties and urgently require life support intervention through ventilators. If the situation further aggravates, septic shock and multi-organ failure may occur, resulting in patients' deaths. Therefore, severe ARDS cases require prophylactic immune modulation and anti-viral in addition to the life support system. Allopathic drug hydroxychloroquine (HCQ) has been used as prophylaxis and therapeutic against COVID-19 because of its multi-action effects on virus multiplication. Nafamostat and camostat can inhibit viral fusion with host cells; thereby, entry of viruses into host cells could be prevented. Viral protease inhibitors like lopinavir, ritonavir, and nelfinavir, could prevent proteolytic cleavage of viral polyprotein precursors into functional units, thereby multiplication of virus is prevented. Remdesivir and ribavirin can

prevent viral replication and multiplication by inhibiting viral enzyme RNA-dependent-RNA-polymerase (McKee et al., 2020). Whereas, Sofosbuvir, zanamivir, and oseltamivir could also inhibit viral replication, viral shedding and infectivity. Emodin as a potent inhibitor of the ACE2-S-protein complex for preventing viral entry into host cells is investigated. Azithromycin, Interferon-alpha, Interferon Beta, and convalescent plasma have also been used to assess their efficacy as anti-viral and prophylaxis. Under severe conditions or ARDS, corticosteroids, tocilizumab, anakinra, IVIg, ruxolitinib, upadacitinib, and baricitinib have been assessed as inhibitors or neutralizing agents against interleukins arising as a result of cytokine storms to manage the severity of COVID-19 (Shetty et al., 2020).

Although a plethora of medicines, as mentioned, have been used to combat COVID-19, no specific, effective, and targeted medicine has been recommended so far. There are currently more than 50 vaccine candidates under clinical trials; many of them have reached an advanced assessment stage. Pfizer/ BioNTech, Gamaleya, Moderna RNA-1273, Oxford's adenovirus vectored vaccine (Ch Ad ox1 nCoV-19), Sinopharm, and Covaxin have been assessed for desired efficacy and approved for emergency use (Folegatti et al., 2020; Kim et al., 2021). Some oral and nasopharyngeal vaccines are also being evaluated, and will hopefully be made available by June and July 2021. Though the world's most extensive covid vaccination program has been started in December 2020 and January 2021, its actual impact would be seen in the coming days.

Need and relevance of plant based molecular defense against COVID-19

The evolution of novel viruses capable of causing human diseases is a natural phenomenon that might go on unceasingly unless we change our lifestyle as per the aims and aspirations of the planetary health concept. Although vaccines are the most potent arsenals against infectious diseases, we cannot afford to invest huge money in the R&D of vaccines. We all know that Hydroxychloroquine, a structural analog of quinine extracted from the bark of Cinchona trees for hundreds of years, formed an early line of defense against COVID-19 (Editorial, Nature Plants, 2020). As SARS-CoV-2 spread fast, we increasingly realised the needs and relevance of plant-based medicines and decoctions as prophylaxis and therapeutics because they are easily accessible, inexpensive and effective against COVID-19. Governments of India and China officially approved the integration of Ayurveda and traditional Chinese medicines, respectively, with allopathic prescriptions and efficacious results were also seen in improving symptoms and curing the disease (Vellingiri et al., 2020; Ren et al., 2020). Drug designing and development often involve intense, rigorous, very expensive and highly time-consuming activities. Therefore, consistent innovative efforts are required to develop anti-viral bio-active molecules from plants since they have always served as natural sources of lead molecules as progenitors of many potent drugs currently being utilised against infectious diseases. Above all, many phytochemicals are believed to be of great potential in possessing synergistic potentials/

actions in combination with allopathic medicines, thereby alleviating the latter's harmful side effects (Narayan, 2019).

Healthy lifestyles necessarily encompass healthy diets and regular exercise to maintain an optimum cellular currency of energy and ATP molecules required for our body to sustain all routine activities cyclically. Fresh food items involving whole food grains, pulses, oils, vegetables, fruits, milk and yogurt constitute a healthy diet that provide all necessary nutrients to our body. Optimum availability of cellular ATP molecules and dietary nutrients is an essential prerequisite for a healthy and resilient immune system to fight off invading viruses and microorganisms naturally. However, such nutritional foodstuffs are not available to all because of socioeconomic disparities. Nonetheless, processed and preserved food habits are also growing parallel to meet the needs of taste-based culture and quick fix lifestyles in urban settlements to buy more time for greater ease, comfort, and enjoyment. Such lifestyles have resulted in the greater vulnerability of all age groups of people to communicable and non-communicable diseases. Hence, there is a growing need to educate people on functional foods and drinks as dietary medicines to save themselves from pain and agonies of respiratory viral diseases, including COVID-19.

Functional food items against SARS-CoV-2

Sprouted peanuts (*Arachis hypogaea*) and grape (*Vitis vinifera*) skins contain a high resveratrol concentration, a stilbenoid and natural polyphenol, which has been demonstrated *in vitro* to inhibit the expression of nucleocapsid protein of MERS-CoV. It also inhibits virus-induced cell apoptosis, hence suggested to be effective for inhibition of multiplication of SARS-CoV-2 as well as virus-mediated apoptosis of host cells (McKee et al., 2020). Therefore, sprouted peanuts may serve as a curative diet as a medicine against COVID-19. Takahashi et al., 2015 have demonstrated through *in vitro* assays that soybean (*Glycine max*) contains ACE2 inhibiting substance, which was identified as nicotianamine (ACE2iSB). Since the ACE2 enzyme serves as receptor for viral spike proteins, nicotianamine could inhibit SARS-CoV-2 to find entry into host cells.

Fig. 2. (A) Dried chopped roots of licorice and food preparation with root extract, candies and confectionaries (B) Sprouts of soyabean

Therefore, sprouted soybean as foodstuff may also be used to block entry of SARS-CoV-2 into host cells, thereby preventing COVID-19 infections (Fig. 2 (B)). Licorice (*Glycyrrhiza glabra*) or *mulethi* is dried roots, conventionally used to chew for clearing sore throat. The root extract is used to prepare candies and confectionery items which can benefit COVID-19 patients upon consumption as a therapeutic diet. Pharmacologically, licorice extract contains glycyrrhizin which has been demonstrated through *in vitro* assays as a potent inhibitor of SARS-CoV-2 entry into host cells and also the multiplication of viruses more effectively than standard anti-viral Rivabirin (Cinatl et al., 2003). Further, Bailly et al. (2020) reported that glycyrrhizin blocks enzyme ACE2 and SARS-CoV-2 attachments based on molecular docking studies, thereby viral entry into host cells would be prevented.

Impressed with glycyrrhizin's medicinal efficacy, Prof. Hong Ding of Wuhan University proposed that diammonium glycyrrhizinate in combination with Vitamin C might exhibit synergistic action in blocking SARS-CoV-2 multiplication in COVID-19 patients as a very effective drug and approved its clinical trials (Editorial Nature, 2020). Recently, Sinha et al. (2020) has reported another bioactive compound, glycerin A, in addition to glycyrrhizic acid from licorice extract (Fig. 2 (A)), which binds with viral Nsp-15 endoribonuclease and blocks replication of the virus inside host cells based on molecular docking studies. Red raspberry, grapes, broccoli, red onion, black tea and leafy vegetables contain quercetin, a natural flavonoid that has been demonstrated to possess a broad range of anti-viral properties. Quercetin displays multi-target action on virus activities, viral entry, viral replication and virus particle assembly. These therapeutic actions of quercetin are further augmented by the co-administration of Vitamin C, which exerts immune-modulatory activity and can also recycle oxidized quercetin. Therefore, co-administration of Vitamin C and quercetin is a safe, effective and inexpensive anti-viral and immune modulation approach for both prophylaxes of high-risk populations and treatment of both mild and severe cases (Biancatelli et al., 2020). Curcumin is a natural polyphenolic compound extracted from turmeric (*Curcuma longa*), a trendy coloring and flavoring food item. It has been successfully used as a bioactive phytochemical with high curative potential for many diseases; therefore, medicinal efficacy of curcumin is approved by the US food and drug administration (FDA). Several studies on anti-viral activities have pointed out the multi-mechanistic roles of curcumin in inhibition of viral entry, replication of the viral genome, and viral multiplication. Curcumin molecules have been demonstrated through molecular docking techniques to interfere with SARS-CoV-2 protease and spike glycoprotein binding with target receptors; thereby, viral entry to cells and replicating the viral genome is inhibited (Utomo et al., 2020). It has also been demonstrated to possess anti-inflammatory and antifibrotic effects by reducing the expression of chemokines and cytokines in human lung infection; thereby, acute respiratory distress syndrome (ARDS) caused by them would be improved. ARDS is the main cause of deaths of COVID-19 patients the world over, requiring a mechanical supply of oxygen to patients through ventilators. Rahman (2020) reported an interesting finding of *Nigella sativa* or black cumin or *kalonji*, which in combination with zinc might be very effective in curing COVID-19 patients. *N. sativa* seeds contain unsaturated fatty acid, proteins, alkaloids, saponins, and essential oil. Thymoquinone and nigellimine are believed to be bioactive components of seeds that can act against SARS-CoV-2 since nigellimine share structural similarities with chloroquine and hydroxychloroquine, so it is expected to perform analogous functions of HCQ. Whereas thymoquinone can inhibit the entry of SARS-CoV-2 into cells, nigellimine can enhance Zn's uptake by host cells similarly, as demonstrated for HCQ. It is known that Zn inhibits proteolytic processing of viral polyprotein precursor; thereby, viral replication is inhibited. Oleoylethanolamide (OEA) is derived from omega-9-monounsaturated fatty acid, oleic acid, which is abundantly present in sunflower oil, olive oil, canola oil, avocado fruits and cheese. OEA has been experimentally demonstrated in clinical trials to decrease angiotensin

receptors' affinity to SARS viruses, thereby prohibiting viral entry into host cells. OEA can also decrease the production of pro-inflammatory cytokines in obese patients; therefore, OEA may serve as potential ARDS symptoms alleviating molecules for COVID-19 patients. Lakshmi et al. (2020) have provided evidence through molecular docking studies for anti-SARS-CoV-2 activities of some Indian ethnomedicinal plants, *Trichosanthes cucumerina* (Snake gourd) and *Piper nigrum* (Black pepper), which are also traditionally used as vegetable and spice, respectively. Cucurbitacin E, cucurbitacin-B, isocucurbitacin-B and bryonolic acid *T. cucurmerina* can inhibit SARS-CoV-2. Main protease 3CLpro, is used to process polyprotein precursor, thereby inhibiting the multiplication of the virus. Whereas piperine of *Piper nigrum* is also an inhibitor of 3CLpro, they together can also serve as immune modulators without adverse side effects. *Cinnamomum verun* (cinnamon) and *Syzygium aromaticum* (cloves) herbal extracts have been used to test their efficacy against SARS-CoV *in vitro* assay and observed to be inhibitory of viral entry into host cells, thereby preventing disease development (Zhuang et al., 2009). Given the structural homology between SARS-CoV and SARS-CoV-2, cinnamon and clove are also expected to inhibit SARS-CoV-2.

Functional drinks and kitchen garden herbs against SARS-CoV-2

Citrus fruits such as oranges and lemons are used in the preparation of refreshing drinks; if the powdered peel is also mixed with a drink, it provides neutraceuticals such as hesperidin, naringin, and Vitamin C, which have been pharmacologically demonstrated to be highly medicinal against COVID-19 based on molecular docking (Fig. 3 (A)). Hesperidin is most abundantly present in peels of citrus fruits. Hesperidin and naringin are bioactive

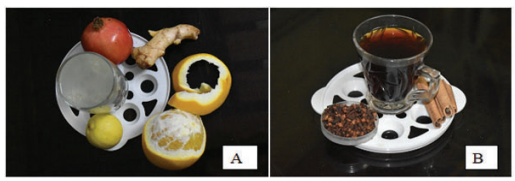

Fig. 3. (A) Juice of orange and lemon mixed with powdered rind of citrus fruits (B) Tea prepared with cinnamon and cloves

flavonoids shown as inhibitors of viral ACE2 and 3CLpro enzymes, which are crucial for viral entry into host cells and multiplication. In contrast, Vitamin C, hesperidin, and naringin can counteract cytokine storms in severe patients, thereby improving ARDS symptoms of COVID-19 patients (Meneguzzo et al., 2020). Bhardwaj et al. (2020) and Ghosh et al. (2020) have reported their findings on tea leaves' bioactive molecules as therapeutics against COVID-19. Tea leaves are a popular non-alcoholic drink in India and many parts of the world. Botanically, tea is *Camellia sinensis* leaves used to manufacture various tea types such as green tea, black tea and oolong tea through different processing methods (Fig. 3 (B)). In molecular docking and molecular dynamics studies, it has been found that oolonghomobisflavan-A, the most abundant polyphenol molecules of tea leaves, was the most potent inhibitor of the main protease (Mpro) of SARS-CoV-2, which can block viral multiplication. When Mopar inhibitory activities of tea leaf constituents were compared with repurposed synthetic allopathic drugs, atazanavir, darunavir, and lopinavir, tea leaf constituents such as olonghomobisflavan-A, theasinensin-D, and theaflavin-3-O-gallate showed superiority

over allopathic drugs. While in green tea, out of 8 polyphenols studied, all exhibited good inhibitory activity against Mopar. However, three polyphenols, epigallocatechin gallate, epicatechingallate and gallocatechin-3 gallate, were the best performers. *Azadirachta indica* or neem is considered one of the most popular medicinal plants, is the source of nimbolin-A, Minocin and cycloartanols which inhibit E and M proteins of SARS-CoV-2; when consumed by COVID-19 patients, these bioactive molecules can interrupt the synthesis of virus particles consequently viral load is considerably reduced. Nimbin-A was the most potent in binding affinity, as demonstrated in molecular docking (Borkotoky et al., 2020).

Fig. 4. (A) *Asparagus racemosus* plant (B) *Withania somnifera* flowering twig

Asparagus racemosus or *shatavari* (Fig. 4 (A)) is a well-known traditionally used Indian herb to enhance immunity, longevity and mental functions. *In silico* study was conducted to identify and evaluate phytoconstituents of the root extract against SARS-CoV-2. Steroidal saponins such as Asparoside-D and Asparoside-C were observed to inhibit spike receptor-binding domains of SARS-CoV-2 by forming stable bonds between them. Whereas Asparoside-D and Asparoside-F were able to form stable bonds with viral NSP15 endoribonuclease, viral entry into host cells and multiplication is inhibited. Quite interestingly, the above binding affinity between phytoconstituents of *A. racemosus* and SARS-CoV-2 proteins was greater than the currently prescribed drug Remdesivir against COVID-19 (Chikhale et al., 2020). *Withania somnifera* is a well-known Ayurvedic herb used as an immunomodulator, anti-inflammatory, anti-viral and anti-oxidant (Fig. 4 B). In the wake of COVID-19, this medicinal herb's phytoconstituents were screened using computational methodologies such as molecular docking and dynamics studies. Withanoside X was found to be a potent inhibitor of SARS-CoV-2 vital proteins, receptor binding domains of spike proteins, and NSP-15 endoribonuclease (Chikhale et al., 2020). Subsequently, Kumar et al. (2020) demonstrated that withanone (active withanolides) could inhibit SARS-CoV-2 main protease (Mopar) and check virus multiplication. Further, Kumar et al. (2020) reported that withanone and withaferin-A stably interact with catalytic sites of TMPRSS2 enzyme of the host that cleaves virus-bound ACE2 receptor and facilitate subsequent membrane fusion of virus and host cells, thereby preventing viral entry into host cells. Straughn et al. (2020), while searching for an alternative natural product to alleviate ARDS symptoms, found that withaferin-A, a steroidal lactone of ashwagandha, could reduce cytokine storms, hence, improves ARDS conditions in severe COVID-19 patients. It also checks the viral entry into host cells by interfering with receptor binding domains of viral S-proteins. Chewing fresh raw leaves of *W. somnifera* empty stomach for a fortnight improves symptoms of allergic rhinitis reactions comparable to anti-histamine, cetirizine. As withaferin-A was observed to be a potent prophylactic and therapeutic against SARS-CoV-2 on account of its multiple actions against the virus consumption of fresh leaves could effectively reduce susceptibilities of allergic rhinitis prone people to respiratory

viruses, including SARS-CoV-2. Given *ashwagandha's* immense utilities in the management of COVID-19, Tillu et al. (2020) also opined that it might be a better and safer substitute for containment of COVID-19 as compared to Hydroxychloroquine.

Conclusion

A pandemic of the magnitude of COVID-19 is a once-in-a-century event. Although the devastating impact of COVID-19 has been enormous on the global economy and human life so far, the present generation of humanity must view it as an opportunity to be an eye-opener for learning valuable environmental lessons. CORONA, an acronym could mean: Compensation or Reversal of Nature's Agony. It reminds us, why did Coronavirus emerge? Because human beings never compensated for the exploitations they caused of nature and natural resources. A minuscule virus, SARS-CoV-2, emerged as an arsenal of Mother Nature to take revenge of ruthless human behavior towards wildlife and threatened species of the planet earth. Investigations for ascertaining the biodiversity source of SARS-CoV-2 are underway at Wuhan. We never got better insights into ecological theory: biodiversity loss is slow poisoning. COVID-19 is an eye-opener for the present generation. Ecologically, biodiversity loss and climate change have been serving as predisposing factors for the emergence of novel Coronavirus, SARS-CoV-2. We do perceive the adverse effects of climate change in our daily life observations. However, unlike climate change, the harmful impacts of biodiversity loss as a silent killer cannot be realised while damage is being inflicted; when catastrophic consequences become apparent, it would be too late to contain it. What exactly happened through COVID-19? Human beings never anticipated the harmful effects of trade and trafficking in wildlife. However, the sudden emergence of SARS-CoV-2 made everybody panic as an international health emergency was declared which abruptly brought about lockdown of all human activities. The global death toll on account of COVID-19 is approaching the 2.3 million mark as of now, and infection and death rates are gradually declining in India and many parts of the world. However, some vaccines have been approved and administered — a matter of great hope and expectations for normalcy. Since pandemics often show a long scaring tail, herbal prophylactics and immunity boosters would stand the test of time. Scientifically, our everyday dietary needs hold great promise. Growing needs of potent preventive nutraceuticals against COVID-19 necessitated pharmacological researches to identify and isolate bioactive compounds from botanical sources that serve our dietary needs. Research and innovations for COVID-19 combat continued with the hunt for potent inhibitors of SARS-CoV-2 proteins and enzymes such as S-proteins, M-proteins, 3CLprotease, Papain-like protease, RdRP, NSP-15 endoribonuclease, ACE2 of host for blocking viral replication in host cells, thereby containment of the disease COVID-19. To date, many compatible bioactive compounds of dietary plant foodstuff origin have been identified that block viral and host enzymes instrumental for viral multiplication in host cells and disease development. Dietary foodstuffs with prophylactic and therapeutic action against COVID-19 virus have been selected — soybean, peanuts, licorice, grapes, avocado, citrus fruits, turmeric, black cumin, black pepper, sunflower seeds, snake gourd, cinnamon, cloves, black and green tea, neem,

shatavari and *ashwagandha* which could be conveniently used as functional foods and drinks against a broad spectrum Covid-variants. Nevertheless, current discoveries of potent prophylaxis, targeted medicines, and vaccines are just emergency measures to tide over the crisis; the ultimate solution to pandemics lies in follow-up and scrupulous adherence to the planetary health concept.

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SCIENCE TEACHING-LEARNING IN ONLINE MODE: A STUDY OF TECHNO-PEDAGOGICAL KNOWLEDGE DEVELOPMENT IN TEACHERS

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Digital Technologies (DTs) are a widely recognised aspect of 21st century skills for teachers. The unprecedented COVID-19 pandemic has forced schools to suddenly close down and shift to complete online teaching. This paper explores the practicalities and reflection of teachers in terms of their confidence in teaching science using various digital technologies during online classes using TPACK framework. The sample constitutes of 81 government and private school science teachers of Delhi NCR (India) and the study used mixed methods approach. The study focused on the four technological dimensions of TPACK i.e., TK, TCK, TPK. It was found that most of the teachers had taken self-initiative to learn and adapt to sudden shift to complete online teaching. Though initially teachers found it daunting and challenging to adapt to completely technology-based teaching, they gradually gained confidence in using various digital platforms in teaching of science. Analysis of the data revealed that increase in teachers' confidence levels was most in TPK and least in TCK. There is positive and moderately high correlation between all domains of TPACK. The findings of this study have implications for professional development programmes which can focus on use of various DTs to support inquiry in science classroom than mere sharing of information.

Keywords: Digital Technologies (DTs), Technological Pedagogical Content Knowledge (TPACK), science teachers.

Introduction

Knowledge and skills of using digital technologies are widely recognised aspects of 21st century teachers. Technology has now moved from being an "accessory" to playing a central role in inquiry teaching. The developments in technology are fast paced and in a short span of time computers have been replaced by interactive phones, mobile technologies, video editing systems, etc., to name a few. This has also led to emergence of internet-based learning systems as the first priority of digital technologies. With the advent of new technologies, science teaching-learning has moved beyond the classrooms and school laboratories to the domains of E-learning portals. However, it is important to understand that digital technology alone would not contribute to the learning process unless it is integrated with content domain and pedagogical knowledge. This study explores the enhancement of digital competencies and skills in science teachers using TPCK or TPACK (Technological Pedagogical Content Knowledge) Framework.

The COVID-19 pandemic in the beginning of 2020 has led to the sudden closure of schools in India and in rest of the world and shifting to online mode of classroom teaching. School education is one of the worst affected areas due to the pandemic (UN 2020, SDG report 2020). Needless to say, science teaching-learning in schools has been

impacted severely as it involves laboratory experiments and hands-on activities. Added to this, is the digital divide, limited availability of devices for online classes, and lack of preparation for conducting online classes and assessment. One entire academic year has passed with many stop-gap arrangements like reduced workload, syllabus, teaching hours, flexible assessment, etc., to mitigate some problems. The teachers' role had been critical in this sudden change from classroom interaction to digital learning or completely online classes. However, teachers have tried to navigate through this crisis by upgrading the much-needed digital skills for online teaching and conducting classes and assessment completely in the online mode for an entire academic year. This paper explores how online teaching and use of DTs has contributed to TPACK development in science teachers.

Theoretical background

The most notable work done in the area of integration of technology with pedagogy and content is by Kohler and Mishra (2006, 2008) i.e., TPACK or TPCK Framework. This framework is an extension of PCK Framework of Shulman (1986). The TPACK Framework has seven distinct domains or categories of teacher knowledge namely Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological knowledge (TK), Technological Content Knowledge (TCK), Technological Pedagogical Knowledge (TPK) and Technological Pedagogical Content Knowledge (TPCK). TPACK Framework is a flexible framework for teacher education and research purpose and can be used for developing teacher readiness for 21st century skills (Fig & Jaipal, 2012; Koehler et al., 2011) and is suitable for various pedagogical orientations (Brantley-Dias & Ertmer, 2013).

Initial research in the area of TPACK in teacher education (in-service and pre-service) focused mostly on technological literacy (Jang & Tsai, 2013) and gradually moved into the integration of technology in PCK components. Review also indicates that high PCK levels increases TPACK confidence (Jang et al., 2010). Studies also focused on effect of training and contexts on confidence and self-efficacy in TPACK (Graham et al., 2009; Voogt 2014), perceptions and self-efficacy (Kiray et al., 2018) and influence of context on TPACK levels of teachers (Owusu, 2015). Studies focusing on technological components of TPACK revealed that self-confidence of teachers was varied in various dimensions. For instance, Graham et al. (2009) found that after intervention, the confidence of teachers ranked from highest to lowest in TK, TPK, TPACK, TCK and in studies based on self-efficacy (Voogt, 2014), the greatest increase in self efficacy was in the order of TCK, TPACK and TPK. Research in the area of TPCK in science education has indicated that digital technology can be used in variety of ways like simulating and modelling science experiments, data collection and manipulation (McCrory, 2008), enhance scientific inquiry (Novak & Kracjick 2006), problem solving (Niess et al., 2009), collaboration and communication skills (Keong et al., 2005). By integrating technology in pedagogical design and specific content domain, teachers not only gain knowledge of content and pedagogy but also engage in dialogue and collaboration (Koehler et al., 2011).

Hence the review of literature indicates that several tools have been constructed to assess TPACK in science teachers. However, there is dearth of literature on research done to assess development of TPACK in the contexts of complete online education. In a recent study, Pareto and Willmark (2019) recommends a need to investigate how TPACK can be developed within practice teaching or teaching context and argues for TPACK development in specific situation and contexts rather than generally addressing. This study explores development of TPACK of science teachers in Delhi in the context of online teaching by using TPACK framework and focused on enhancement of confidence levels in using digital technologies.

As mentioned before, the TPACK framework consists of seven dimensions. However, this study focusses on four components or dimensions namely TK, TCK, TPK and TPACK as the focus is on use of digital technology for effective science teaching during pandemic induced online education. Here, Technological Knowledge (TK) refers to teachers' knowledge and understanding of various software and digital tools. Technological Pedagogical Knowledge (TPK) refers to teachers' knowledge of impact of a particular technology on the pedagogy and Technological Content Knowledge (TCK) refers to the knowledge of suitable technologies to integrate with specific content. The last dimension TPCK or TPACK refers to knowledge of how technology, pedagogy and content relate to each other and strategic use of technology in a particular context. This knowledge is 'dynamic and adaptable as per the needs of students and teaching context' (Mishra & Koehler, 2006).

Research Focus

As mentioned previously, the use of technology in science teaching-learning is widely recognised as important aspect for promotion of scientific inquiry. In the Indian context, teachers have been using various digital technologies like web-based resources, simulations, interactive white boards, power point presentations, assessment strategies like quiz, etc., in science classrooms and laboratories in schools. However, most of the time the choice was with the teacher as to when and what to use. Apart from the textbook transaction through lectures, the hands-on activities, laboratory activities, demonstrations etc., were part of dominant discourse of science teaching. Digital technologies were mostly used to supplement classroom teaching. However, the sudden shift to online classes in schools and universities in India has put the use of digital technologies to the forefront. Those teachers who were novice to technology had to adapt suddenly to this mode. Even the teachers who were familiar with digital technologies had to adapt them to suit to online classes and students who do not have access or have limited access to digital devices. Informal conversations with teachers revealed that this entire experience had been 'learning while teaching'. Some teachers shared that they did some activities and demonstrations at home and shared the videos to explain science concepts. Teachers tried to innovate within the digital constraints.

So, in the process, many teachers have learnt new skills and gained confidence in using digital technologies effectively. Hence, one can say that the pandemic had created a context to learn, explore, adapt and adopt new skills of using digital technologies. This

study focusses on this aspect of enhancement of confidence levels in using various digital technologies in science teaching-learning and how it had contributed to the development of TPACK in teachers. The study has implications for further professional development of teachers and how science teaching-learning can take place more effectively in future in online or blended mode. Hence the following research questions formed the premise for this study.

1. How has online teaching contributed to development of TPACK in science teachers?
2. What are the confidence levels of teachers in using various digital technologies in science online teaching in the four domains of TPACK i.e., TK, TCK, TPK and TPCK?

Methodology

This study was conducted in Delhi NCR in India and used mixed methods approach. The following sections discuss the methods and materials used for data collection and analysis.

In order to understand the ground realities of online teaching in the schools , five government school science teachers (mentor teachers) and five private school science teachers were interviewed. For this purpose, mentor teachers and coordinators who were actively involved in mentoring were chosen. The government school teachers were mentor teachers who were coordinating with a number of schools in that particular district and private school teachers were coordinators or senior teachers in their schools. Telephonic interviews using semi-structured questionnaire were conducted. The interaction helped to get an insight into the various school activities pertaining to teaching-learning and assessment in general and science in particular, during online mode of teaching. This was followed by the second stage which involved data collection from 81 science teachers of Delhi NCR. The following section describes the development of tool, sample and methodology.

Tool: A lot of research has been done in designing a psychometrically sound tool or questionnaire to measure various dimensions of TPACK, both in areas of pre-service and in—service teacher education. Some of them are original TPACK by Koehler and Mishra (2008), SPTKTT by Schmidt et al. (2009), Chai, Koh and Tsai (2013), Bilci et al. (2013), Valtonen et al. (2017). Some of these questionnaires measured all dimensions, whereas some like Valtonen et al. (2017) measured only dimensions related to technology i.e., TK, TPK, TCK and TPACK necessary for 21st century teaching skills. Some questionnaires were designed to gauge the confidence and self-efficacy of pre-service/in-service teachers, whereas others gauged their knowledge in these domains. Review of these tools by keeping in mind the research questions helped to frame a questionnaire to collect data from in-service science teachers. The questionnaire also consists of adapted version of few items from the literature review of standardised tools focusing only on TK, TPK, TCK and TPACK. The questionnaire had total 30 items divided in four sections as TK (10 items), TCK (5 items), TPK (10 items) and TPCK (5 items). All the questions were based on a five-point rating scale. The teachers were asked to rate their confidence levels ('not at all confident' to 'completely confident') in using

various digital technologies in the TPACK framework as compared to their experiences prior to the sudden shift to online teaching. There was also one open ended question seeking the information about the challenges and difficulties experienced by the science teachers. The reliability of tool was statistically tested and Cronbach's alpha came out to be 0.951. As it is greater than 0.7, the tool was found to be reliable. The questionnaire was anonymous and was circulated through Google Docs Link.

Sample: The final sample consists of 81 science teachers of both Private and Government schools in Delhi NCR in India. Snowballing sampling technique was used. Teachers who were using only WhatsApp medium to teach or sending notes and worksheets were not considered in this study. Perhaps due to this reason, the sample of government school teachers is less than private school teachers. Only those teachers were considered who were willing to participate in this study voluntarily and reflect on their experience of online teaching. The teachers were assured of complete anonymity and that the data no way reflects their professional competencies and will not be shared with any administrators. Table 1 represents the demographic profile of the sample.

Table 1: Sample Profile

Gender	Male Teachers	11.1%
	Female Teachers	88.9%
Age Group	20-40 years	36%
	Above 40 years	64%
Type of School	Government school	35.8%
	Private school	64.2%
Qualifications	Graduation	7.4%
	Post-Graduation	75.3%
	M.Phil./Ph.D.	17.3%
Teaching Experience	Less than 5 years	6.4%
	5 to 15 years	37%
	15 to 25 years	32.1%
	More than 25 years	24.5%

Statistical analysis of the data was done using SPSS and an attempt was made to triangulate the quantitative data with qualitative data emerging from interviews and open-ended question of the questionnaire

Results and Discussion

Analysis of interviews with the government school mentor teachers and private school teachers gave insight into how the online teaching of science was carried out in most schools. The government teachers shared that science teachers in each district were connected in groups through messenger platforms like WhatsApp. Few expert teachers used to share videos of their own experiments and demonstrations. Few sessions on use of basic digital technologies were organised by calling resource persons. The mentor teachers also shared that the resources like videos, presentations, worksheets in some topics were posted for teachers. Also, some teachers were asked to record their teaching of lessons in the school setting and these

recordings were shared within the group of teachers. Teachers were allotted topics on rotation basis. These videos were also shared with students so that they can study at their convenient time. As compared to private schools, the frequency of online live classes was less in government schools as many students in government schools were not able to attend classes due to lack of devices at the time of teaching. Also, teachers shared that resources from DIKSHA portal were used. The private school teachers shared that they used apps like 0-LABS for simulating experiments. Companies like Edumart were invited to conduct sessions (one or two only were conducted per subject). Teachers also used YouTube videos and self-made presentations extensively. For making questionnaires and assessment they used CBSE test generator, Microsoft and Google forms, quiz apps.

The analysis of data emerging from questionnaire given 81 teachers regarding using digital technologies in science classrooms in the various domains of TPACK is discussed in the following paragraphs.

Technology Knowledge (TK): Technology Knowledge (TK) broadly refers to "the understanding of application and limitations of various technologies and skills to use them efficiently". It also encompasses the interest of teachers in keeping up with new technologies. Keeping these in mind, ten questions were framed to understand science teachers' knowledge of digital technologies and confidence in using them during online classes. Teachers were asked to rate their confidence level compared prior to the online classes on a five-point rating scale. Regarding basic pre-requisites of technological knowledge, majority of teachers (67.5%) are completely confident and 26 per cent are quite confident in searching website for information. 81 per cent have become completely confident in saving an image from website. Other aspects in which teachers have become quite confident are keeping up with new technologies, taking and editing a digital photograph and 56 per cent have become completely confident in creating documents with graphics. In other technological skills like producing a video clip, use of blogs and podcasts, the confidence levels are less than previous aspects as only 17.5 per cent are completely confident in producing videoclip and 21 per cent have gained complete confidence in using blogs etc. One area in which majority of teachers have not become confident is in creating own websites, blogs, YouTube channels, etc., as only 9 per cent are completely confident and hence needs training. Figure 1 illustrates the confidence levels of teachers in various aspects of TK. The increase in confidence levels can be attributed to the fact that many of them were involved in active learning while teaching. One teacher shared that "Everything was challenging initially as I had no exposure to any online medium except sending email, typing question paper and entering marks. But in this one year, I have learnt so much as it was need of the hour".

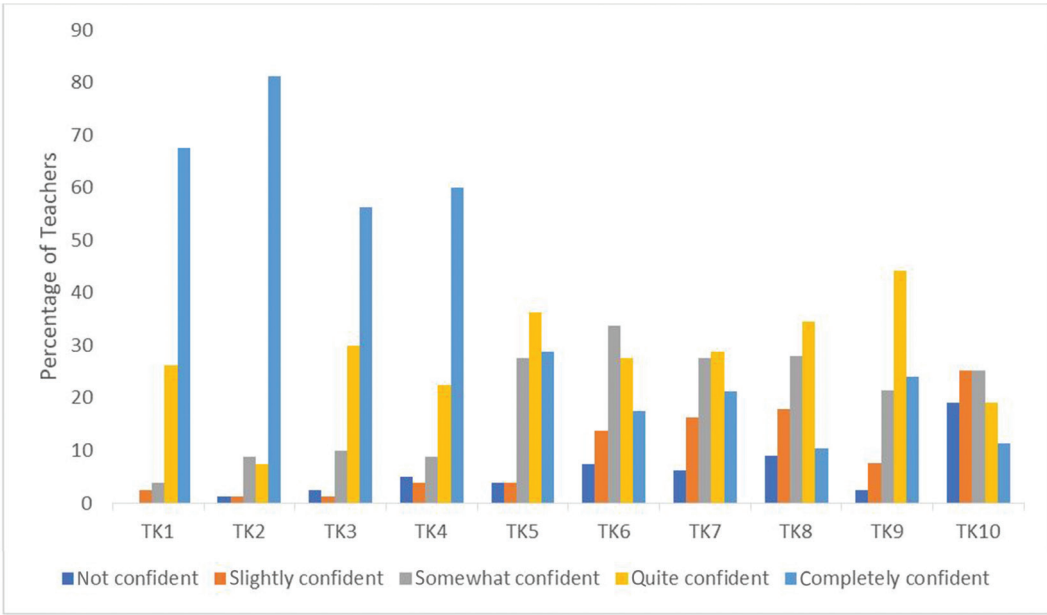

Fig. 1. Aspects of Technological Knowledge (TK) Dimension

Table 2: Mean Scores in various aspects of Technological Knowledge (TK) dimension

Item	Aspect	Mean Score	SD	Government school teachers		Private School teachers		p-value
				Mean	SD	Mean	SD	
TK 1	Search website for information	4.58	0.69	4.46	0.92	4.65	0.51	0.242
TK 2	Save image from website to documents	4.66	0.79	4.14	1.11	4.94	0.30	0.002*
TK 3	Create document with graphics	4.36	0.90	3.92	1.15	4.59	0.63	0.001*
TK 4	Create PPTs with visuals and graphics	4.28	1.10	3.71	1.35	4.59	0.79	0.00*

TK 5	Take and edit digital photographs	3.82	1.02	3.57	1.25	3.96	0.83	0.102
TK 6	Produce and edit video clip	3.34	1.15	3.25	1.32	3.38	1.05	0.620
TK 7	Using blogs, podcasts, etc.	3.42	1.18	3.28	1.43	3.5	1.01	0.441
TK 8	Troubleshooting ICT related problems	3.19	1.13	2.96	1.33	3.31	1.04	0.194
TK 9	Keeping up with new technologies	3.80	0.98	3.71	1.04	3.84	0.94	0.579
TK 10	Create own website, blogs YouTube channel etc.	2.78	1.28	2.67	1.33	2.84	1.25	0.587
		3.80	0.74					

*Significance level at 0.05 assuming equal variance

In order to know the differences between responses of government and private school teachers, the data was subjected to two-tailed t-test using SPSS package. It is found that at significance level of 0.05 assuming equal variances, there is no significant differences between the responses of the two sets of teachers except in three area represented by items TK 2, TK 3 and TK 4 (Table 1). These areas in which there is significant difference in the responses between government and private school teachers in creating documents with graphs, creating presentations with visual effects. The mean scores of private school teachers are higher than government school teachers and this may be attributed to the reason government school teachers were mostly using videos and resources from the common pool or repository of resources created as shared by the mentor teachers in the interviews while private school teachers were creating their own resources.

Technological Content Knowledge (TCK): The next set of items focused on teachers' TCK. TCK refers to "the teachers' knowledge about various technologies which are used within the content and understanding of the connection between content knowledge of the subject and technology. Integrating technology with the content effective knowledge and using some of the technologies and applications used by scientists and professionals, using technology for data collection and analysis and modelling scientific phenomenon using technologies are some aspects which comes under the domain of TCK. Teachers were asked to rate their confidence levels

in these aspects during online teaching as compared to their experiences of pre-pandemic classroom teaching. Majority of teachers (41%) have expressed that they are completely confident in integrating digital technologies with content successfully. Majority of teachers are somewhat confident (35%) and quite confident (30%) in using digital technologies and applications used by scientists and other science professionals like advance programming softwares, simulations, virtual lab activities, etc., and modelling scientific phenomenon either using simulations or programming and only 16 per cent have gained complete confidence in this area. However, only 8 per cent of teachers have become completely confident and 26 per cent somewhat confident in modelling scientific phenomenon. This implicates need of training workshops specifically in the area of modelling scientific phenomenon. Using digital technologies to demonstrate science experiments as using virtual lab activities is very important in the online teaching especially in the absence of opportunity of real experimentation in the laboratories. As shared by private school teachers in the interviews, many teachers have used O-LABS for simulating experiments (example shared was demonstration of Ohms' law). Also, teachers use videos created by publication companies (examples given were Pradeep classes, H.C. Verma, etc.) to explain the concepts and expressed that they were able to integrate successfully. The responses of teachers in TCK dimension are represented in Figure 2.

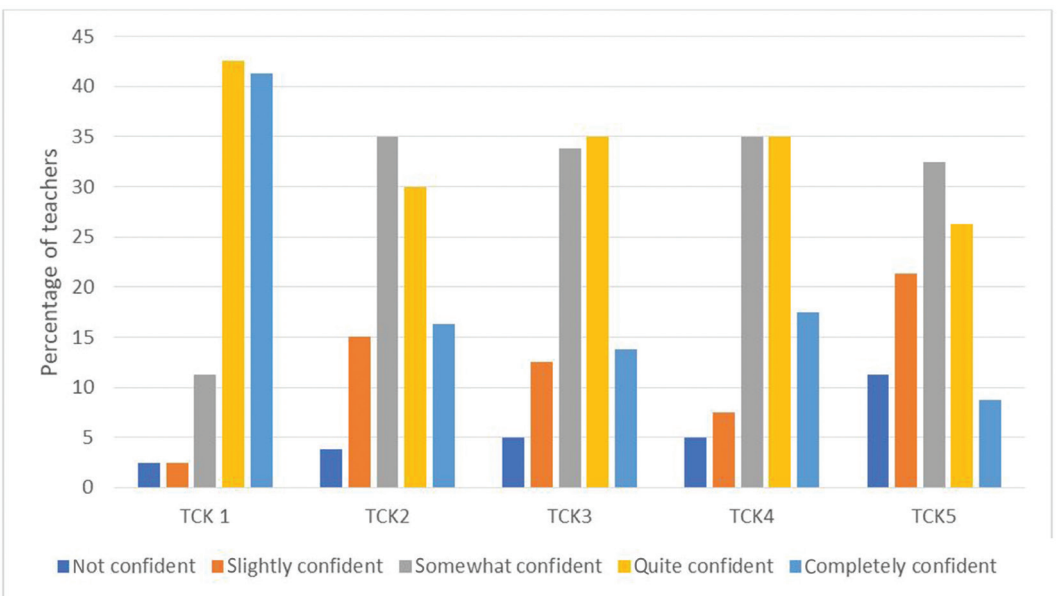

Fig. 2. Aspects of Technological Content Knowledge (TCK)

Table 3: Mean scores in various aspects of Technological Content Knowledge (TCK) Domain

Item	Aspect	Mean	SD	Government school teachers		Private school teachers		p-value
				Mean	SD	Mean	SD	
TCK 1	Integration of content	4.17	0.91	4.14	1.04	4.19	0.841	0.819
TCK 2	Using digital technologies used by scientists and professionals	3.40	1.05	3.35	1.17	3.50	0.988	0.536
TCK 3	Using applications by professionals	3.40	1.04	3.37	1.13	3.46	0.991	0.667
TCK 4	Using technologies for data collection	3.52	1.03	3.52	1.38	3.54	0.980	0.946
TCK 5	Modelling scientific phenomenon	3.00	1.14	2.98	1.2	3.04	1.11	0.838
		3.5	0.88					

In order to know the differences between responses of government and private school teachers, the data was subjected to two—tailed t-test using SPSS package (refer Table 3) and it is found that at significance level of 0.05 assuming equal variances, there is no significant differences between the responses of the two sets of teachers.

Technological Pedagogical Knowledge (TPK): TPK refers to teachers' knowledge and understanding of the nature of teaching-learning on integrating with technology and choice of pedagogical practices which amalgamate suitable technologies. So, in order to understand teachers' confidence levels and self-efficacy in using digital technology for effective pedagogy, classroom management, assessment, 10 items were posed. Majority of teachers expressed increase in confidence levels in using digital technologies during online science classes for effective communication (65%), class management (78%), assessment (73%), effective presentation of topics (78%) and for motivating students (75%). However, in the open-ended questions, majority of teachers also expressed these aspects as challenges.

Analysis of open-ended question on challenges faced reveals that high absenteeism, lack of eye contact, effective feedback mechanism,

and less scope of personal interaction were issues faced by majority of teachers. The responses of teachers in TPK dimension are represented in Fig. 3. Majority of teachers have expressed increase in confidence levels in engaging students in collaborative work, problem solving and 44 per cent are somewhat confident in using ICT for promoting critical thinking as group projects were given to students. However, only 27.5 per cent are confident in thinking critically the choice of technology in science classroom. There are still quite a number of teachers who have to gain more confidence in using technology in these areas (Refer Fig. 3). Majority of teachers also expressed gaining confidence in choice of tools for effective classroom transaction, indicating that teachers have spent a lot of time in exploring various tools of digital technologies for their teaching.

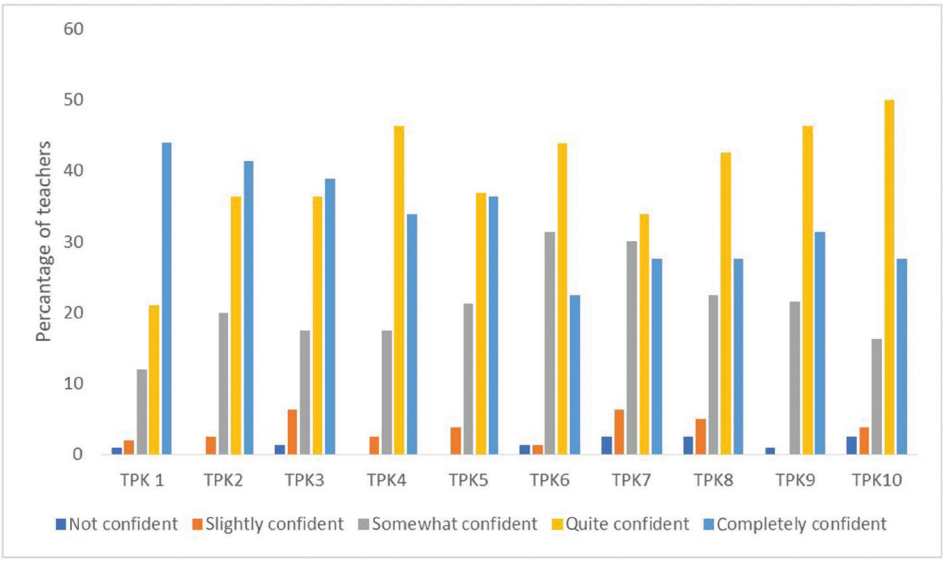

Fig. 3. Aspects of Technological Pedagogical Dimension (TPK)

Table 4: Mean scores in various Aspects of Technological Pedagogical Knowledge (TPK) Dimension

Item	Aspect	Mean	SD	Government school teachers		Private school teachers		p-value
				Mean	SD	Mean	SD	
TPK1	Using DTs for effective communication	4.30	0.91	4.00	1.12	4.48	0.727	0.023*
TPK 2	Using DTs for effective class management	4.16	0.83	4.04	0.92	4.23	0.78	0.321

TPK 3	Using DTs for motivating students	4.05	0.97	3.82	1.12	4.17	0.85	0.121
TPK4	Effective presentation of content	4.11	0.78	3.93	0.98	4.21	0.64	0.122
TPK5	Using STs for assessment	4.07	0.85	3.96	1.04	4.13	0.74	0.398
TPK 6	Use of DTs to promote critical thinking	3.85	0.83	3.82	0.98	3.87	0.74	0.823
TPK 7	Use of DTs for collaborative work	3.77	1.01	3.68	1.05	3.83	0.98	0.533
TPK 8	Promoting DTs for problem solving	3.87	0.96	3.79	1.03	3.92	0.92	0.545
TPK 9	Enhance pedagogy	4.06	0.80	3.96	0.96	4.12	0.70	0.424
TPK 10	Critical choice of DT tools	3.96	0.91	3.89	0.99	4.00	0.86	0.617
		4.00	0.75					

*Significance level at 0.05 assuming equal variance

In order to know the differences between responses of government and private school teachers, the data was subjected to two-tailed t-test using SPSS package. It is found that at significance level of 0.05 assuming equal variances, there is no significant differences between the responses of the two sets of teachers except in item TPK 1 i.e., for effective communication (refer Table 4). Here the mean scores of private school teachers are significantly higher than government school teachers and reason may be ascribed to more digital divide in government school students. Due to this, communication between teachers and students during the class may be hindered or not taking place much. This is supported by the qualitative analysis of open-ended question seeking information on challenges faced where majority of teachers have shared that lack of devices for the students or sharing of devices within family is a major issue during online classes.

Technological pedagogical content knowledge (TPCK): Next set of questions addressed teachers' TPCK which refers to their understanding about integrating content knowledge with pedagogical and

technological knowledge. In this all the three domains i.e., content, pedagogy and technology are integrated for meaningful and effective learning in science.

Majority of teachers have gained confidence in using digital technologies in — engaging learners in scientific inquiry 33 per cent have become completely confident and 38 per cent somewhat confident in using online simulations for demonstrating scientific principles and activities. Though majority of teachers said that they have become confident in identifying and addressing learners' misconceptions, they may be referring to the conceptual understanding as most of them were using MCQs for assessment. In facilitating science activities in the online mode ,no one is completely confident whereas 42.5 per cent are quite confident. The responses of teachers are represented in Figure 4.

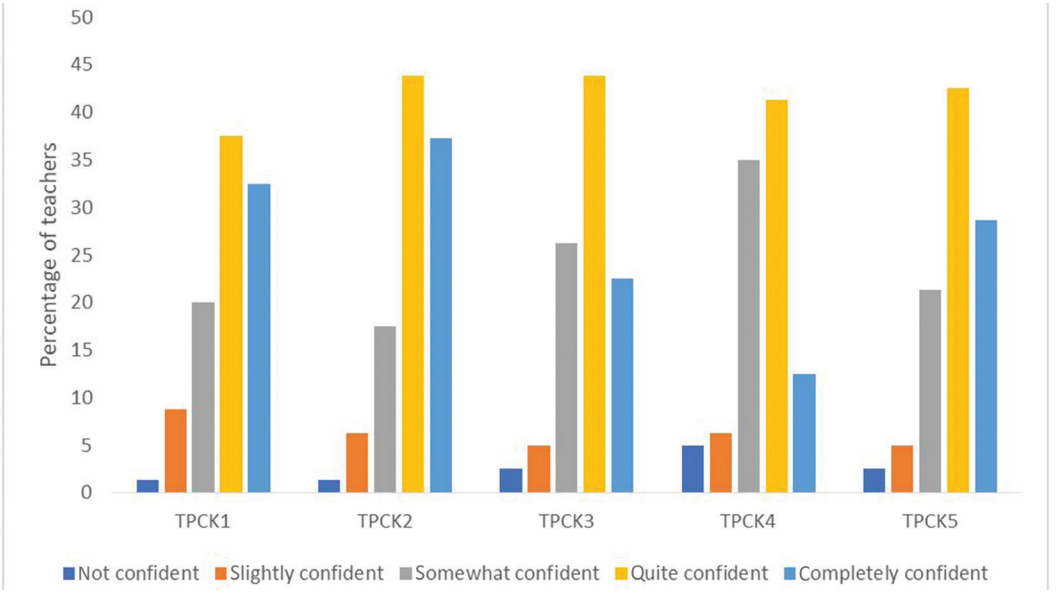

Fig. 4. Aspects of Technological Pedagogical Content Knowledge (TPCK) Dimension

Table 5: Aspects of Technological Pedagogical Content Knowledge (TPCK) Dimension

Item	Aspect	Mean	SD	Government school teachers		Private school teachers		p-value
				Mean	SD	Mean	SD	
TPCK 1	Using DTs for demonstration of scientific principle	3.91	1.0	3.68	1.18	4.04	0.86	0.132
TPCK 2	Using web resources for identifying and addressing misconceptions	3.97	0.93	4.0	1.08	3.96	0.84	0.861

TPCK 3	Using DTs for facilitating scientific inquiry	3.79	0.94	3.86	1.01	3.75	0.91	0.629
TPCK 4	Using DTs for Modelling scientific phenomenon	3.50	0.97	3.68	1.02	3.40	0.94	0.228
TPCK 5	Using DTs for facilitating science activities	3.90	0.96	3.89	1.03	3.90	0.94	0.962
		3.8	0.83					

In order to know the differences between responses of government and private school teachers, the data was subjected to two-tailed t-test using SPSS package. It is found that at significance level of 0.05 assuming equal variances, there is no significant differences between the responses of the two sets of teachers in any aspect of TPCK (refer Table 5).

Associations between various domains of TPCK

In order to find out the correlations between various domains of TPACK, the data was analysed using SPSS and correlation coefficients are depicted in the Table 6.

The analysis reveals that there is positive and moderately high correlation between various dimensions of TPCK indicating that technological knowledge, technological content knowledge has effectively translated into and technological pedagogical content knowledge.

Table 6: Correlation between various domains of TPACK

		TK	TCK	TPK	TPCK
TK	Pearson Correlation	1.00	0.72	0.75	0.72
TCK	Pearson Correlation		1.00	0.72	0.78
TPK	Pearson Correlation			1.00	0.76
TPCK	Pearson Correlation				1.00

Correlation is significant at the level 0.01 (2-tailed)

Conclusions and Implications

This paper explored the practicalities and reflection of teachers in terms of their confidence in teaching science using various digital technologies during online classes. This study found that teachers, though initially found daunting and challenging to adapt to complete technology-based teaching, gained confidence in using various digital platforms in teaching of science. Most of the teachers had taken self-initiative to learn and adapt to sudden shift to complete online teaching situation created by the COVID-19 pandemic. The study focused on the four technological dimensions of TPACK i.e., TK, TCK, TPK and TPCK and analysis reveals that increase in teachers' confidence levels is most in TPK and least in TCK. This implicates that teacher were confident in using and integrating various pre-prepared digital technologies in their classroom pedagogy but need to enhance their technological content knowledge i.e., knowing more about advanced DTs like data collection and modelling tools for scientific inquiry. There is positive and moderately high correlation between all domains of TPACK. It is also found that "learning communities" created seems to have positive impact on teachers' using of various DTs and continuous support is needed to overcome inhibitions and challenges.

The findings of this study have implications for professional development programmes which can focus on use of various DTs to support inquiry in science classroom than mere sharing of information. Bell and Gilbert' Model (2004) which focus on collaboration among the teachers for effective professional development can be designed in more sustained manner.

The professional development programs and in-service training workshops need to focus on integrating technology for scientific inquiry and empower teachers to use advance technologies for simulations, virtual lab activities, data collection and modelling of science phenomenon.

This study is significant in terms of using DTs in science teaching in authentic context i.e., when teaching is completely based on extensive and continuous use of online medium rather than an occasional or additional use as accessory. The pandemic has created a new 'world view' in education (Tsybulsky and Levin 2019) of integrating novel technologies in learning and it cannot be successful without teachers' beliefs and confidence in adapting to digital technologies for not merely to sharing of information but rather for more inquiry driven science discourse in classrooms.

Limitations and Scope for Further Research

This study focused only on teachers' perspective and gain in their confidence level in using various digital technologies in science teaching. The study did not involve an in-depth comparison between the government and private school teachers on various aspects of TPACK and reasons for it. Further studies can be undertaken to assess the effectiveness of various technology-driven online classes on students' understanding of science concepts, their attitudes and motivation. Action research studies on the basis of reflection of teachers can also be undertaken. Research is needed in terms of teacher preparedness for blended learning models in the future. NEP 2020 also emphasises on digital literacy and digital

integration in curriculum and pedagogy. Future researches can focus on teacher and institutional preparedness for this. As digital divide has been quoted by majority of teachers as big challenge and hindrance for successful integration of technology, further research is needed in this area for successful initiatives to overcome digital divide for an unhindered learning. As this study focused only on school teachers in cosmopolitan area of Delhi NCR, further research is needed to gain insights about the use of digital technologies for science teaching and teacher preparedness in rural and semi-rural areas.

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PEOPLE'S AWARENESS ON CORONAVIRUS DISEASE (COVID-19) IN THE CONTEXT OF ITS TRANSMISSION AND EPIDEMIOLOGY — A STUDY

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A study on the awareness of Coronavirus Disease (COVID-19) with 124 randomly selected people of Bhubaneswar reflected that 81 per cent of people believed it to be a killer disease. Very limited people had knowledge about symptoms of the disease. Less than 50 per cent understood about transmission of the virus, by mouth droplets. Though 42 per cent of people believed that masks could prevent disease transmission, a large number of people were found using masks improperly. A positive relation was found between education and awareness, but, age was found to have no impact on people's awareness. In the absence of a vaccine or drug to control COVID-19, the possible means of preventing the disease and people's awareness have been discussed.

Keywords: COVID-19, people's awareness, education.

Introduction

One of the major challenges faced by humanity in the current century is the threat due to the novel corona virus (COVID-19). The disease first surfaced in Wuhan City (Hudei province) of China in December 2019, which started as a Zoonotic disease — nonhuman to human transmission. Within no time, the coronavirus as a pandemic spread all over the world and altered the pace, fabrics and nature of people's lives. It has spread to over 218 countries globally, infecting about 83.8 million and killing 1.8 million till the end of December 2020, turning it into a global pandemic. India is no exception, with confirmed infection and death rates increasing in number every day. The possible source of origin of the Indian SARS-CoV is from Europe and Oceania regions besides the Middle East and South Asian regions (Mondal et al., 2020). The World Health Organization (WHO) officially declared the SARS-CoV-2 outbreak as a public health emergency of international concern on January 30, 2020 and a global pandemic on March 11, 2020.

The disease produces flu-like symptoms. With virus receptors being on the upper respiratory tract and lungs (Wu, 2020), the infection spreads easily, and the virus is more virulent than flu. Most infections cause mild disease, and the rate of fatality is 1–3 per cent depending on host factors and health care quality. The severity of SARS-CoV-2 infection is more in persons with a weak immune system and infants. A total of seven virus strains have been reported from different locations of the world (Pandey, 2020), and virulent forms are appearing over time.

In the absence of any specific drug and preventive vaccine to control COVID-19,

preventive measures such as quarantine and lockdowns are the only possible means to curtail the spread as urged by WHO. With this background, the present study was undertaken to understand public awareness about the prevention of the disease, which in turn can influence public co-operation for compliance with government guidelines.

Conceptual background

Besides being obligate parasites, viruses are host-specific and tissue-specific (Ananthanarayan and Paniker, 2012). COVID-19, though said to have originated from some wild hosts, has established in the human system and multiplies in the respiratory tract. This RNA virus is highly contagious and spreads through respiratory droplets that come out through sneezing, coughing, or talking and subsequently inhaled by a healthy person nearby. Further, when a healthy person shakes hand with an infected person or touches some objects with the virus on it and then touches their mouth, eye, or nose, the infection spreads.

Like any other non-vector-borne virus disease, COVID-19 epidemiology involves three components, host (human being), pathogen (Coronavirus) and the environment (Fig. 1).

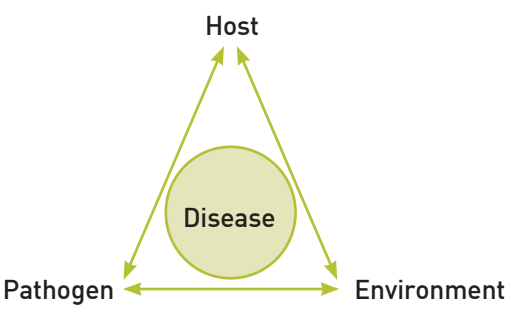

Fig. 1. The Disease Triangle

When all the three components unite forming the disease triangle, the infection takes place, and under favorable environmental conditions, disease outbreak occurs, leading to the global epidemic. It is a polycyclic disease and many disease cycles occur in a short time leading to its fast spread. Coronavirus spreads slowly in hot and humid weather compared to cool and dry conditions (Rao et al., 2020). Any break between host-pathogen or pathogen-environment, or host-environment links reduces the chances of infection, leading to a decline in disease spread.

Material and Methods

The present study was carried out in the Niladri Vihar market area of Bhubaneswar, the capital city of Odisha. The total sample population taken for the study was 124 randomly selected persons within the age of 15-65 years. There were 38 females and 86 males in the total sample population. Age-wise and education-wise distribution of the sample population has been depicted in Fig. 2a and 2b, respectively. Both qualitative and quantitative data were collected through verbal questions in this survey.

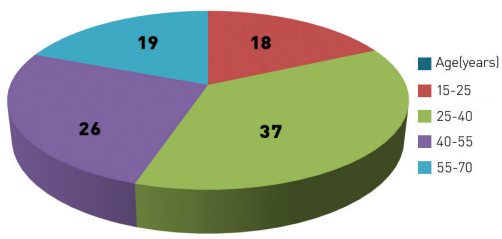

Fig. 2a. Age-wise distribution of the sample population

Out of 10 questions, six questions were related to symptoms, transmission, source of knowledge, etc. Four questions were about their practices, such as wearing masks, washing hands, social distancing in gatherings, and isolating or quarantine of those with symptoms. For practices, quantitative data were collected on 3 point scale - 0 when the answer is no, 1 when partly correct and 2 for the correct answer. The percentage of response was calculated from the total sample population.

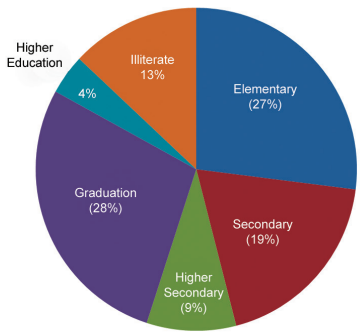

Fig. 2b. Education-wise distribution of sample population

Statistical analysis such as regression and correlations were carried out from the data following IRRISTAT 91.1 software, and the results have been presented diagrammatically (Fig. 3 and Fig. 4).

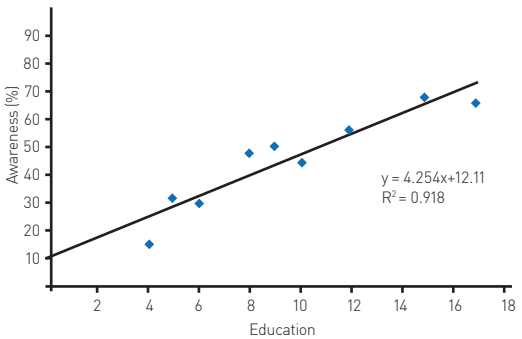

Fig. 3. Relationship between Education (Years) and Awareness.

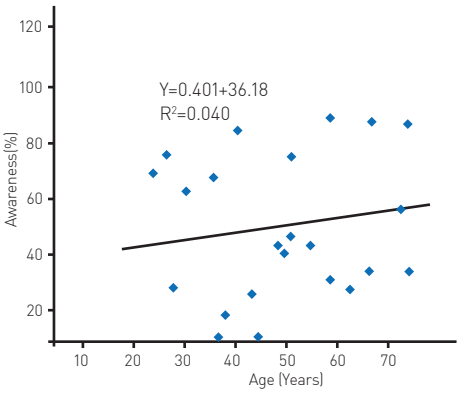

Fig. 4. Relationship between Age (Years) and Awareness

Result and Discussion

COVID-19 is a compound interest polycyclic disease. The killer disease spreads very quickly because of the fast multiplication of the virus and a relatively short incubation period (average ten days, range 3–14 days) of the disease. It is interesting to see the observation and reaction of the people about the disease (Fig. 5).

The disease has created a great panic among the people. Regarding the nature of the virus, about 60 per cent people believed it was a killer disease, 15 per cent termed it as a ghost possibly as they neither could imagine about the pathogen nor its source. About 81 per cent of people were scared of the disease as the time and place of infection is uncertain and beyond imagination. Further, this could be because the disease that kills some infected persons, which is a matter of uncertainty. Regarding symptoms of the disease, most people were aware of one or the other symptoms of the disease (Fig. 6).

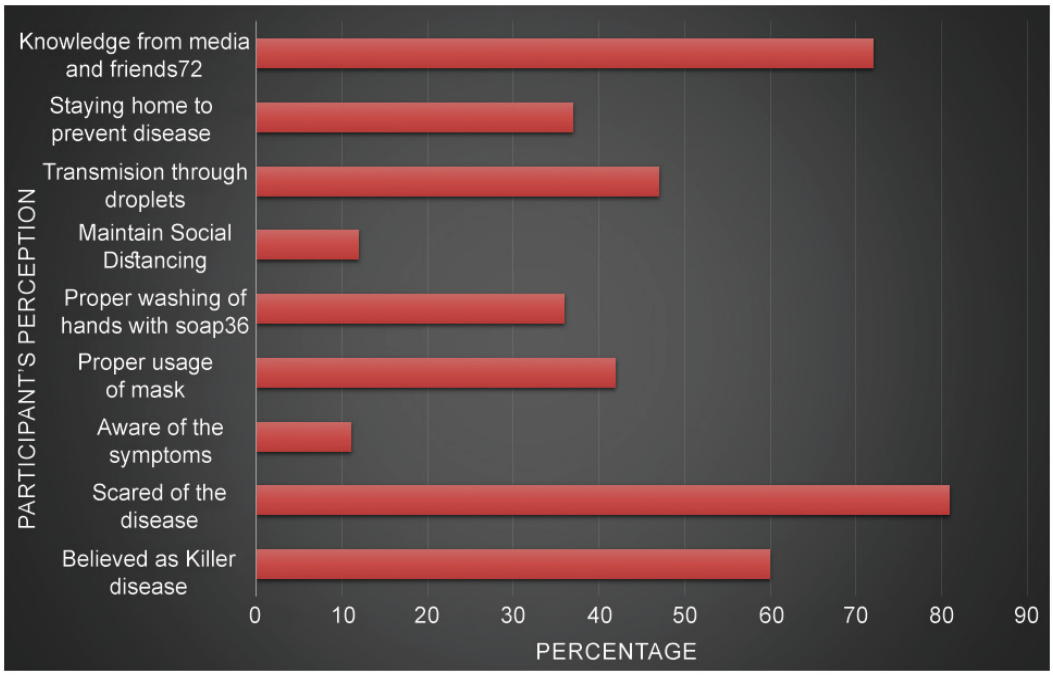

Fig. 5. Participant's perception (%) of COVID-19

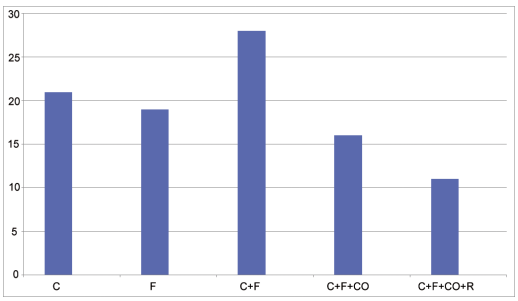

Fig. 6. Symptoms of COVID-19 as observed by the sample population (%)
Nature of symptoms: C = Cold, F = Fever, CO = Cough, R = Respiratory problem

Only 11.0 per cent of people were aware of all the major symptoms (cold, fever, cough and respiratory problems) associated with the disease, whereas 21 per cent and 19 per cent believed cold and fever, respectively, as the only symptom.

Regarding the possible method of controlling the disease spread, 42 per cent of people believed that the disease could be prevented by putting on a face mask. Thirty-seven per cent of the sample population realized that staying at home is the best possible means. Regarding the mode of transmission, 47 per cent of people believed it to be through the mouth, 31 per cent and 30 per cent said that it could be due to staying together and touching the infected person's body, respectively, but none could answer that it could be because of all possible means.

Regarding the use of masks, about 18 per cent of the sample population were found without it (face mask) and 37 per cent were found to use it improperly. Concerning washing hands, 54 per cent replied that they

do not regularly wash their hands with soap or detergent. About keeping a distance in crowded places, 98 per cent people noted they fail to keep a reasonable distance in the market and other crowded places. Looking into the source of information about the coronavirus, most people (72%) observed that they could know about the disease from print and electronic media (mostly TV) and friends.

Over time, it was observed that people are increasingly using the mask, but the disease still spreads. This could be because of an increase in inoculum (virus) load in the environment and its wide spatial distribution due to the movement and migration of workers.

The relationship between education in years and awareness scores was positively (R^2 = 0.098) co-related (Fig. 3). A unit (in year) increase in educational level was found to enhance awareness by 4.25 per cent. This reflected that increase in educational level increases people's awareness regarding the prevention of COVID-19 spread. The relationship between age in years and awareness score was poorly (R^2 = 0.04) established (Fig. 4). It reflected that age has no relationship with people's awareness.

As a whole, people do not follow appropriate practices. Further, the availability of the inoculum in terms of infected persons and the closeness between the inoculums/sick person and the healthy person determines the chances of infection and subsequent disease spread. Some of the predisposing factors, such as the host's age, morbidity issues, cold and moist weather, crowded population, lack of ventilation, etc., promote the fast spread of the disease (Rao et al., 2020).

In social distancing (keeping a gap between the diseased and the healthy person), the chances of nasal drops carrying the virus reaching a healthy person get reduced. WHO observes that with keeping a distance of at least 1.0 meter, chances of breathing in droplets gets reduced. Many countries have different guidelines. In Canada and India, it is 2.0 meter while in the USA, it is 1.8 m. In Australia and Germany, the distance is 1.5 m. China and Singapore advise keeping a distance of 1.0 m. Besides distancing, other measures that influence mitigation are the number of people in a given space, duration of proximity (how long sick and healthy person stay and work together), use of face mask, and whether people talk quietly or shout. With loud voice, the chances of droplets getting dispersed become high. In gatherings and/ or crowded habitations (such as slums), in the absence of ventilation/ free air, infection chances become still high (Ramamurthy & Srivastava, 2020). An ICMR report has shown that a COVID-19 patient can infect 406 patients if preventive measures are not followed, such as lockdown and social distancing (Anonymous, 2020). A study from quarantine centers in Odisha states that those factors have played a very important role in increasing infection levels. In complete isolation, the transmission cycle is forcefully broken, reducing inoculums level in the environment. A study from Nigeria found that most people adhered to government policy guidelines, with 92,7, 96.4 and 82.3 per cent people adhering to social distancing, improved personal hygiene and using a face mask, respectively [Rueben et. al., 2020].

In washing hands and face with soap and detergent, the viral outer lipoprotein layer gets lysed by the detergent and the viral

particles are washed out as their spike proteins are removed from the skin surface. With divergence in variation in genetic makeup in the host population (human beings), asymptomatic persons are observed. They act as potential transmitters (John, 2020) possibly being tolerant and increasing the risk of disease spread. With a change in host physiology and environment, such asymptomatic persons become potential spreaders and play an active role in disease spread without their knowledge.

Experts over the world have argued in favor of wearing a mask. If two persons meet and neither is wearing a mask, the risk of transmission is high. If one of them is wearing the mask, the risk is medium, and if both are wearing the mask, the risk is low because of double barriers that stand between the host and the pathogen. The basic philosophy of wearing a mask is "I protect you, and you protect me." However, it was noted in the present study that a good number of people wear the mask on the chin or under the nose and try to pull it up and down. This type of wearing is meaningless and increases the person's chance of contracting an infection. In the present study, it was realized that some people believed wearing a mask was troublesome and shameful. A section of people feel shy as they feel that they may not be presentable with a mask. In spite of the limitations, it is important to wear a mask that fits well, covering the person's nose and mouth.

As many people in our country are not conscious as well as do not wear a mask properly, it needs to be made mandatory. People have to develop a habit and inculcate a sense of responsibility of wearing masks as and when going outside to benefit the self as well as the community. It is interesting to note that in Malaysia though 83.4 per cent of the population avoid crowds, only 50 per cent wear a face mask [Azim et al., 2020]. Studies in many countries such as the US, UK, Italy, Jordan, and China reflected that people, as well as health workers, have good knowledge, optimistic attitude, and good practices on preventive measures, which hopefully has controlled the disease spread over time (Puspitasari et al., 2020). It has been noted that Japan has been more resilient to the disease outbreak due to good hygiene and habits like wearing masks and avoiding handshakes. In the US, it has been observed that with 80 per cent of the population wearing masks, the number of infections came down by 92 per cent, but when the percent of mask-wearing came down to 30–40 per cent, it almost had no beneficial effect. It could be due to the fact that people in the US became casual in wearing a mask with relaxation in government guidelines and people's mobility [Mukharjee, 2020].

Besides hygienic practices, there has been a considerable focus on the possible development of a vaccine in recent times. Social media is highlighting reports of the development of new vaccines every day. However, vaccine development is a slow process that needs to be executed with meticulous planning, and it seems impossible to have a vaccine very soon for immediate use [Mukharjee, 2020].

As advised by the epidemiologists, lockdown, though slows down the spread of infection considerably, does not stop infection because of minimum person-to-person contact. Further lockdown is not a possible solution

in the long run as livelihoods are lost, and the economy is pushed into the doldrums. The disease could stop only when most people develop herd immunity after getting infected and survive the infection. Under this situation, our fight against coronavirus is far from over. We have to learn to live with the virus (Ramamurthy and Srivastava, 2020), which has an important role in determining society's readiness to accept our behavioral change to avoid crowds, wearing a mask, maintaining social distance, etc.

Under this situation, masks and physical distancing besides hand-washing are very important to reduce an individual risk to exposure and subsequent disease spread. It is interesting to note that in 1918 during the Spanish flu, as many as 20-50 million people died (Ramamurthy and Srivastava, 2020) and in the absence of a vaccine or drug, citizens were ordered to wear a mask that helped to reduce disease spread.

Conclusion

From the study, it was concluded that community-based health campaigns are urgently needed in the current time to create awareness, remove misconceptions about coronavirus, and promote appropriate practices such as washing hands, social distancing, keeping away from shaking of hands besides wearing a mask. As such, covid—appropriate behavior as decided by the government from time to time needs to be followed by each and every individual irrespective of age, education, place of residence and socio-economic back ground to eradicate the inoculum and control the disease.

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DELIBERATING ON ENVIRONMENTAL EDUCATION AND ITS PRACTICES DURING THE COVID-19 PANDEMIC

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The article deliberates on the epistemological debate that exists in the field of environmental education in the context of the present pandemic situation. Humans have always considered themselves to be the most evolved species so far so that the relationship they shared with their environment was also being defined by them as a phenomenon that existed because humans existed. Although, the contrary view existed but the anthropocentric worldview dominated even after being challenged by the other worldviews. The advent of the pandemic situation affected the human life more than any other life on earth. Moreover, the basic needs required for human survival during the pandemic conflicted with the practices that have been prescribed through the anthropocentric view in environmental education. This raises crucial questions on the worldview that had been predominating the field. Hence, the article revisits and deliberates on the existing perspectives of environmental education and its practices taking the context of COVID-19. pandemic. The two major positions/worldviews underlying the core of environmental education — anthropocentric and the eco-centric have been discussed taking relevant cases and arguments. The article corroborates the need for operationalising the eco-centric view in environmental education.

Keywords: Environmental education, anthropocentric, eco-centric.

The Context

The COVID-19 pandemic will be earmarked as a period in human history that has brought about a paradigm shift in the way humans controlled the world and associated practices. Humans almost lost control over their own lives, and the freedom to explore and engage with the world around them was restricted. It is thus perceived more as a period of survival than that of living. Humans have always considered themselves to be the most evolved species in terms of the development of the brain and managing other species in their environment. In fact, relationship the humans shared with their environment was also being defined by humans themselves as a phenomenon that existed because humans existed. Although the pandemic made us realise that it was noumena (an idea in philosophy that reality existed irrespective of the observer and is beyond human experience), the relationship was not comprehensible only the way humans perceived, but there was more to it. The humans could not see that they were also a part of the 'noumena' that we refer to as 'the environment' in a phenomenal sense. This is the epistemological debate that existed in environmental education that I feel surfaced with the pandemic situation. Thus, this article revisits and deliberates on the existing perspectives of environmental education and its practices in the context of the COVID-19 pandemic.

Environmental Education and the Worldviews

Environmental education is a multidisciplinary as well as a transdisciplinary field that draws in from other disciplines. It has the prime objective of creating awareness and sensitivity amongst people towards their environment. The definition of environmental education as given in the Belgrade Charter is aligned to these goals that see environmental education as a process for the development of a world population that is aware and concerned about the environment and the issue in it. The definition also specifically states that environmental education should also develop along with knowledge, motivation, commitment and skills to apply that knowledge for addressing the problems and preventing new ones. It emphasises both individual and collective action (UNESCO-UNEP, 1976). Tilbury (1997) also defines environmental education as essentially an education involving the head (knowledge), heart (responsibility), and hand (skills). Thus, another interesting facet about environmental education is that it is a practice/action-based field with an exceedingly small core that is constituted largely of discourses, perspectives, and worldviews established through various policies or international initiatives in the form of conventions/ conferences. The core of a discipline generally has central concepts and formal theories around certain subject matter that is claimed to be universal, but environmental education being interdisciplinary, has a larger peripheral space. The peripheral space is occupied by the practices/ actions emerging from the worldviews that influence the field and the insights gained from various disciplines. This is also a more dynamic and contested space as it comprises all the debates and discourses emerging from one or more disciplines. Such as, whether at the school level, environmental education should be seen from an interdisciplinary approach which implies it to be a separate subject in the curriculum, or from a multidisciplinary approach which implies that it should be infused in all other subject areas of the school curriculum. Both approaches come from different stances based on theories of child development or learning and have their specific implications.

The two major positions/worldviews underlying environmental education are the anthropocentric position/worldview and the eco-centric position/worldview. John Arthur Passmore gave anthropocentrism as a concept in his book *Man's responsibility for nature: Ecological Problems and Western Traditions* (1974) that places humans as the only and most important entity in the entire universe. This perspective asserts that nature has its value only to the extent it is valuable to human beings, and its existence is for serving humans. Thus, the view visualises humans as the managers and controllers of nature. Hence, this worldview looks at the environment and its processes totally from the human perspective. Whereas the concept of ecocentrism focuses on the interaction between humans and nature. Its roots are found in the classical text — A Sand County Almanac: And Sketches Here and There (1949) by Aldo Leopold, where he emphasized that the entire universe is significant as a whole and that humans were only a part of it. It affirms that there exists a harmony amongst various components of nature of which humans too are a part and hence implies that human action within optimal limits

contributes to the environment rather than disrupting its processes.

If we look at the various international initiatives, we find that both worldviews existed. These international initiatives, whether in the form of declarations, charters or summits, had reflections of either of the worldviews. Some focused entirely on the human needs and survival taking an anthropocentric worldview {The Stockholm Declaration, 1972; The World Conservation Strategy (International Union for Conservation of Nature and Natural Resources, 1980); The Rio Declaration (Earth Summit, 1992); United Nations' Sustainable Development Goals, 2015} whereas others did acknowledge the intrinsic value of nature taking an eco-centric position {The World Charter for Nature, 1982; Our Common Future (The World Commission on Environment and Development, 1987); The Earth Charter 2000 (World Summit on Sustainable Development, 2000)}. Although the coexistence of both worldviews thus got echoed in various government policies and actions too, the idea of sustainable development that emerged eventually was specifically critiqued for being anthropocentric. Though sustainable development asserts for environment protection along with economic and social development, it is for the future generation of humans and hence is considered to be deeply anthropocentric (Ganowicz, 2016). The basic premise in sustainable development is to utilize the natural resources for human consumption and development in such a way that it remains available in the long run too. Hence, the idea of conservation is for the benefit of the human rather than for nature to sustain itself. It aligns with the anthropocentric view in reiterating that nature is for serving human interests primarily and that humans are the real managers of nature. In the same context, Fisher (1997) argues that sustainable development is a concept used to justify what humans do for their growth with certain goals, strategies and perspectives. Another aspect on which sustainable development is critiqued is that although it includes both nature and development, more emphasis is given on development for humans than on conservation of nature (Sachs, 1997).

The above discussion shows the dominance of the anthropocentric worldview that even sustained after being challenged by other worldviews. In response to the above scenario, Washington et al. (2017) proposes that the academicians should take the lead in establishing the eco-centric view. A similar vision was entrusted in the past on environmental education by International Union for Conservation of Nature (IUCN), 1980 in its section 13, which is as follows; "A new ethic, embracing plants and animals as well as people, is required for human societies to live in harmony with the natural world on which they depend for survival and well-being. The long-term task of environmental education is to foster or reinforce attitudes and behavior compatible with this new ethic."

The case of *Valley of Flowers* would help us to understand the two positions better. As we all know, *Valley of Flowers* is situated in Uttarakhand that was notified as a National Park in 1982. Since it got the National Park status, as a conservation attempt, livestock grazing was banned in it. This led to a controversy as the scientists at the Forest Research Institute (FRI) contended that due to the ban on grazing, the weed *Polygonum polystichum* increased, adversely

affecting the plant diversity. Botanists and environmentalists believed that processes like 'grazing' were essential natural processes for self-regulation; i.e., they helped the environment regulate itself. Hence, in this case, the animals that visited the valley were grazing, specifically, the weed *Polygonum polystichum,* controlled the growth of this weed and, in turn, helped the biodiversity of the valley flourish. They indicated 'overgrazing' affected the conservation of important species in the region and not grazing.

Thus, this case indicates that the environment has self-regulatory mechanisms. This is aligned to the eco-centric view of environmental education that perceives the environment from an ecological perspective as a holistic system (Leopold, 1949). Ecocentrism realizes the intrinsic value in all lifeforms and ecosystems themselves, including their abiotic component and various processes; as in this case, it was 'grazing' that was regulating the diversity found in the valley. Hence, it is considered the widest of all the worldviews, including biocentrism that focuses on inherent value to all living things and zoocentrism that sees value in animals. On the other hand, anthropocentrism values other lifeforms and ecosystems as they are valuable for human well-being, preferences, and interests. Also, it sees individual humans and the human species as more valuable than all other organisms. Ecocentrism goes beyond by including environmental systems as wholes and their abiotic aspects. It also goes beyond on account of explicitly including flora and the ecological contexts for organisms. Thus, it affirms that humans are part of the ecological system, as other organisms are interrelated through various processes that regulate the system. This approach sees the environment as an independent dynamic system made of various components that are mutually dependent on each other. Thus, environmentalists with this approach claim that 'no action is the best action.' They argue that the human intervention beyond a point disrupts the self-regulatory mechanism in the environment, leading to various issues that remain unresolved. The human intervention is based on the other anthropocentric approach that sees humans as placed in the center of the environment as the most important species capable of sustaining the environment. The later approach defeats the idea that the environment is self-sustainable and could only be realized when one sees it holistically rather than reducing it into its components. As has also been stated by Kopnina and Coci (2017, p.3), *the studies of environmental values indicate that people with eco-centric orientation are more likely to act upon their values in order to protect the environment* (Kortenkamp & Moore, 2001; Stern, 2017; Stern, 1994). Also, anthropocentrism is considered as one of the main drivers of the current ecological crisis (Washington et al., 2017). In fact, environmentalists consider the eco-centric as a worldview that is essential for achieving sustainability. As Washington et al. (2017) assert; "...a fully sustainable future is doubtful without an eco-centric value shift that recognizes the intrinsic value of nature and a corresponding Earth jurisprudence."

Thus, the two main worldviews, anthropocentric and eco-centric, differ in terms of values that they attach with nature which are instrumental and intrinsic, respectively. As we have already discussed, 'instrumental' is a term that signifies the way nature was useful to humans. Hence,

the anthropocentric view relies on the instrumental value of nature, that is, all actions are taken as they are useful for humans (Casas and Burgess, 2012; Donnelly and Bishop, 2007). The term 'intrinsic' has certain complexities that have made environmentalists see other worldviews, too, between the two major ones. Intrinsic primarily refers to seeing the value in nature and the obvious question is who is seeing this value. Callicott (1992) argues that humans see value in nature and that the value of nature depends on humans. He refers to this as another worldview called anthropogenic view, which means that human beings generate the values. The caveat to this view is that it does not mean that the value attached should only benefit humans. Anthropogenic is different from anthropocentric, such as appreciating the patterns in nature or the rhythms or aesthetic value of nature may not be beneficial for humans yet, humans value it. Thus, environmentalists acknowledge anthropogenic as a significant worldview that, unlike anthropocentric view, transcends selfish human interest and thus is referred to as non-anthropocentric by Hargrove (2003). Cocks and Simpson (1995) refer to the view of extreme eco-philosophers who challenge the idea that values are ascribed by humans only and that nature has value independent of humans. This is precisely the noumena-phenomena dichotomy that has been referred to earlier in this article. Rolston (2008) also claims that intrinsic value means the value that was inherent in the living. But, on the other hand, environmentalists Norton (1984) and Callicott (1992) argue that the values that humans did not attribute were meaningless. Hence, they reclaim the idea of an 'anthropogenic view' to make nature and its value comprehensible for humans. Thus, the value of nature, whether instrumental or intrinsic, is perceived by humans. It is the humans who are thinking beings, and the value of nature assigned by them has major implications for the environment. Similarly, environmentalists from an anthropocentric view also see it in two ways: strong anthropocentrism and weak anthropocentrism. They defend that the instrumental perspective of nature (VanDeVeer & Pierce, 2003) was strong anthropocentric, whereas there existed weak anthropocentric that was more related to values assigned to nature. They believe that weak anthropocentric as a worldview was closer to the eco-centric view and was aligned to the benefit of both nature and humans (Norton, 1995). Although they find the intrinsic value of nature as a common element between the two, we need to understand that the eco-centric view was also based on the premise of a self-regulatory aspect of nature of which humans are a part.

In this context, an environmentalist James Lovelock (1972), has hypothesised the idea of 'Gaia'. The Gaia hypothesis proposes that all organisms and their inorganic surroundings on earth are closely integrated to form a single and self-regulating complex system, maintaining life conditions on the planet. So, he perceives earth as a Supra organism. The fundamental basis of the Gaia hypothesis is that the earth functions as a single organism. Just as an organism controls its internal systems for its benefit, so too does the earth sustain itself in a condition of homeostasis. This means that the earth regulates the atmosphere, the lithosphere (the earth), and the hydrosphere (the oceans, rivers, and water vapor) in a way that optimizes conditions for itself. This hypothesis thus

establishes that the earth and its environment are self-regulatory, and humans are part of it. Although the Gaia hypothesis is challenged and critiqued on several grounds, yet the idea has an implied understanding that humans too are one of the components of the environment. Hence, the processes as well as the changes in the environment were beyond the control of humans. In fact, it claims that the changes in the environment were responses to the changes taking place in it, including those that were due to human action. Rowe (1994) provides a similar argument when he mentions that "all organisms are evolved from earth, sustained by earth. Thus earth, not an organism, is the metaphor for life. earth, not humanity, is the Life-center, the creativity-center. earth is the whole of which we are subservient parts. Such a fundamental philosophy gives ecological awareness and sensitivity an enfolding, material focus" (https://is.gd/rkSgP5). He sees ecocentrism as a 'universal belief system' and based on a 'scientific rationale.'

Rowe (1994) acknowledges it as a value shift i.e., ecocentrism being a change in the focus from humans to the earth by imagining earth as a symbol of life. Ecocentrism considers earth or the ecosphere as a being rather than focusing on any one species such as humans. Thus, according to him, ecocentrism gives more value to earth than humans that are merely a part of it.

Another interesting example to support the idea of self-regulation has been depicted in M. Night Shyamalan's Science fiction movie *The Happening* (2008 film). The movie shows that overpopulation in cities led trees to give out certain gases. These gases released by the trees affected humans' neurological systems in such a way that they start getting suicidal tendencies. Thus, the overpopulation of humans is being controlled through the release of gases by trees. Although it is fiction emerging from the writer's imaginative thinking, the idea is based on the possibility of earth regulating itself and its components.

If we look at the practical implications of both worldviews, we see that environmentalists have submitted that both may lead to similar experiences/ actions. Such as 'planting a tree may be an action taken by people with both worldviews. But, the person with an anthropocentric view may be looking at the instrumental value of the tree in terms of its products or benefits for humans whereas a person with an eco-centric view may focus on the ecological role of the tree. Hence, the intent of the action may be different and influenced by the respective worldview. Similarly, the subsequent actions may be different such as, the person with an anthropocentric view may use the tree excessively without giving it time to replenish itself. Whereas the person with an eco-centric view may be more concerned about the tree and the micro-ecosystem that it would have created around itself. Considering that the worldviews may not always have a direct influence on the actions, but Cocks and Simpson (2015, pp. 222–223) assert that the distinction is important for people engaging with environmental education as:

- The motive or intent and the motivation may be different in both cases.
- It has been seen that overlooking this distinction may lead to by default a predominance of one view, that is, the anthropocentric view.
- Not focusing on the distinctions between the worldviews may lead

to foreclosing of the debates and deliberations in the field.

- The discussion or deliberation on the two contrasting worldviews expands the conceptual understanding of academia and helps them look for alternative experiential possibilities.
- The discussion on the plurality of worldviews is considered relevant knowledge for everyone as it helps people reflect on their stance.

Environmental education has always been witnessing this debate of whether to prescribe action or no action was the best action. It reflects the implications of anthropocentric and eco-centric views, respectively. The anthropocentric view focuses on environmental education as action and practice-oriented discipline where the premise is that specific actions may lead to conservation of the environment. Thus, the focus is on conserving nature for humans. Hence, Cocks and Simpson (2015) go to the extent of referring to anthropocentrism as a philosophical elaboration of the term conservation. Callicott (1986), an environmental philosopher, highlights the significance of environmental ethics and that for environmental ethics to be consistent, they should have moral consideration. According to him, ecocentrism is the most consistent ethical theory as it provides moral consideration to the whole ecosystem. Its practical implication is that it limits human behavior that might, beyond a point, have an adverse effect on the environment and helps them live in harmony with its environment. (P. 392). This reiterates the discussion above that overgrazing in which humans may involve their domesticated animals may affect the biodiversity and not simply grazing. The next section deliberates on some of the indigenous practices that have contributed towards the conservation and sustenance of the environment in its natural form to a large extent.

Living in consonance with nature: A synoptic view of the indigenous ideas

In earlier times, people were completely dependent on the local ecosystem for their living. This helped them to develop unique insights into their environment. They were informally able to accumulate a multitude of knowledge about the environment and its concerns in various forms. The indigenous tribes worldwide have folk knowledge that has proved to be valuable for humankind to form a balanced relationship between them and their natural environment which continued to provide consistent support for their survival in every condition. Indigenous peoples' knowledge, conservation related beliefs and values, environmentally adaptive and sensitive land use, resource management practices, and determined defense of territory and natural resources have enabled many of them to inhabit the natural habitats for centuries without destroying their ecosystems and biodiversity (Sterens, 1997).

Similarly, in India, many ancient communities had developed a deep relation, respect, and reverence for the natural environment and planet earth. The lifestyle and belief of conserving the environment date back to ancient Vedic times wherein all the four Vedas and Puranas have in some way expressed the power of all-natural entities. For example, today we know with scientific proof that the sun is the ultimate energy source that regulates the flow of energy in the biosphere.

But this was probably well realized by the indigenous tribes and societies because they worshipped Sun as God, which was incredibly significant in Vedic worship. Similarly, flora and fauna have also been regarded as sacred. The tribal pockets in Dindori, Balaghat of Madhya Pradesh, Bilaspur of Chhattisgarh State, and many other tribes conserve plants in their natural habitat (Rai and Nath, 2003). Plants and trees like Sandalwood, Tulsi (*Basil*), Bael (*Aegle marmelos*), Banyan (*Ficus benghalensis)*, etc., holds special importance in various religious practices (Kaur, 2015). Plants like *Acorus calamus*, stem bark of *Bunchania lanzan*, etc., were conversed by the tribal herbal healer in the forest because it is used as an antidote of snakebite and hence considered holy (Rai and Nath, 2003). They believe that all flora-fauna and other natural entities have awareness and can experience joy and pain (Sahni, 2008). Many animals and birds like cows, bulls, peacocks, eagles, etc., are considered holy. They have symbolic significance in India as vehicles of God. Likewise, all rivers like Ganga, Brahmaputra, Godavari, etc., are worshiped in many cultures, and scientifically, we know that the river water has many minerals and properties which are good for health. Natural entities like mountains (*Vidhyanchal parvat*, Himalaya parvat in North, *Velliangiri parvat* at the Western Ghats, etc.) that inhabit huge biodiversity in their respective areas have been valued for their immense number of natural resources. Indigenous culture and practices were supported majorly by bio-centric and eco-centric values under which they give value to all living beings. They treated every creature on this planet, including the microbes, as of great and equal importance. This faith attached the feeling of sacredness to all forms of life. This shows that they believed in keeping the harmony between humans and the environment, which motivated them and generations to maintain the ecological balance.

Thus, through various rituals, customs, and practices, a rich tradition of love and a sense of belonging had been evolved among all sections of ethnic tribes. According to Chapple (1998), it was understood by indigenous people that the well-being of the environment is dependent on the protection and preservation of the environment. Hence as discussed above, in ancient times, the gurus and the traditional societies had formed a culture of living in synchronization with the natural surroundings. They promoted such guidelines and directives for all people of the societies, which became the way of living for them. This was broadly reflected in the knowledge, lifestyle, and attitude of ancient societies' population towards the plants and animals, rivers, land, rain, air, sun, moon, etc. The knowledge, beliefs, customs, and religious practices around the concept of food value, medicinal use, sacred species, sacred landscapes and other elements of the environment has been communicated through education by formal, non-formal, informal agencies like gurukuls, school, colleges, universities, family, mass media, etc. in all eras. Presently, when the entire world is going through COVID-19 pandemic, environmental imbalance, and degradation, it is all significant for us to understand and practice the indigenous ideas!

Deliberations during COVID-19 Pandemic

The COVID-19 pandemic time can be seen as a phase that has affected human life more than any other life on earth. Humans have been

confined to their homes and have witnessed flora and fauna restoring their spaces in an environment that humans had inhabited. There is no denying that most people appreciated this as a phenomenon, captured it, and disseminated it through social media. But the question arises that whether this appreciation for nature would persist after the pandemic gets over or humans would again reconquer those spaces, being oblivious to the fact that the spaces were shared by other beings of nature too. Cocks and Simpson (2015) mention that the experiences of feelings such as awe, respect, and love towards nature may require an eco-centric perspective. However, at the same time, they admit that the feelings may not have a direct correlation with the environmental perspective, considering that every experience has an element of subjectivity in it (Dewey 1938). There are past experiences of every individual that may influence his/her present experiences that makes his/her experience unique and different from others. Also, as discussed earlier, the reactions may be the same in people with both perspectives, but the intent and motivation behind the same feeling or action may differ. Hence, it is difficult to analyse the feelings people have been expressing and sharing about nature during this phase. Similarly, if we look at the practices, we find that the basic needs required for survival during the pandemic conflicted with the practices that have been prescribed through the anthropocentric view in environmental education. Such as, during the pandemic, people are advised to wash their hands after each hour and that too for at least 20 seconds. This implies that water use has increased substantially, and the efforts to monitor this increase are not a priority, as is human survival. Similarly, to make social (physical) distancing possible, personal transport was encouraged rather than the use of public transport, which contradicted what was prescribed for controlling air pollution. In the same way, to combat this deadly disease, the production of masks and sanitizers was all of a sudden increased without evaluating this practice against any norms that the environmentalists may prescribe. Also, the masks' disposal and the kinds of material they were made of in terms of biodegradability were also not much questioned or pondered upon. Thus, we see that the actions are taken or practices being followed based on the anthropocentric view were provisional and not holistic enough to persist the changes/challenges in the environment. It gives us an opportunity to rethink our actions and align them to the eco-centric view's larger perspective. Washington et al. (2017) gave several examples of how anthropocentric view permeated various approaches and strategies both in governance and academia. They give preference to the term ''ecosystem services' and analyse it as an anthropocentric term that projects nature as a service provider for humans, whether for habitat, nutrients, or energy. They also critically examine the use of economists' term 'sustainability and see it as an anthropocentric term, as discussed earlier, focusing on the minimum biophysical requirements for human survival. The article quotes several environmentalists — Miller (2014); Doak et al. (2015); Batavia and Nelson (2016) who have challenged the 'new conservation' approach for being anthropocentric, also reiterated that this view places humans at a different pedestal.

While deliberating on the fate of the pandemic, medical researchers are also hypothesizing based on the cyclical processes of nature.

They anticipate that the infection rate may go down when around 70 per cent of the human population in a particular region would get infected. This is based on the idea of 'herd immunity' that is, when a large population of members in a community get infected and develop natural immunity against a particular pathogen, the pathogen may not have a big pool of hosts. This decreases the rate of the transmission of the pathogen automatically. Hence, medical practitioners also depend on the natural processes that are prevalent within a community. As expressed by Washington (2013), ecocentrism as a worldview is a reminder that the ecosphere and all life forms are interdependent. He has highlighted the importance of nature's ecosystem processes and that both humans and non-humans were dependent on these processes. These processes are self-regulatory and maintain the balance in nature without any deliberate intervention by humans.

Conclusion

In the contemporary world, we witness that people in rural and tribal areas are living in harmony with their environment and are engaged in the natural processes. Their actions and practices are embedded within the natural processes of their environment. An understanding of these practices can contribute in a large way to operationalising the eco-centric view of environmental education. The underlying idea, however, remains eco-centric worldview is based on ecological thinking. The implications of this discussion include the epistemological assumptions that we attach to environmental education concerning the two major worldviews. Also, it stimulates us to re-envision environmental education and its practices as whether to be an amalgamation of proposed prescriptions that are scientifically derived or implemented. The other alternative is to leave it as an open-ended domain where the teachers, environmentalists, and other stakeholders can have their worldview of environmental education and can evolve their practices that are spatially and temporally contextualised. Within the eco-centric worldview, we may also expect to establish a correlation between the emergence of COVID-19 and environmental changes. If this were possible, we would realize a new world and a discourse on environmental education where humans see themselves as part of the environment!

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DIGITAL LITERACY AS A CHALLENGE FOR STUDENTS TO ATTEND ONLINE CLASSES DURING COVID-19 PANDEMIC: A CRITICAL ANALYSIS

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The recent revolution in digital technology has changed almost every aspect of our lives: how we communicate, work, enjoy our leisure time, and use the source of knowledge and information. At present, children are comfortable using different digital tools. However, it does not imply that they are digitally literate. The key here is that they still need to be supported and guided to be digitally literate. This will greatly propel their learning. All the more, digital literacy is significant for the first-time user especially due to challenges brought by the pandemic situation. Students' pressing need to attend online classes forced them to be digitally literate, which was neglected earlier. Considering this existing gap, this study aimed to identify students' digital literacy and the challenges faced in online learning. This survey-based study used the data from 100 students of Jawahar Navodaya Vidyalaya (JNV) Jethian, Gaya and D.A.V. Medical Unit, Gaya, India. The study revealed that the students need support and guidance to be digitally literate to enhance their learning experience. In this backdrop, the focus of different educational institutions needs to realign to address these challenges and prepare students equipped with digital competencies.

Keywords: Digital literacy, online classes, digital competencies.

Introduction

The sudden outbreak of Coronavirus Disease-2019 (COVID-19) pandemic has affected 1.26 billion students worldwide (United Nations, 2020). It became challenging for the teachers to teach in a physical setting. The teachers looked for opportunities that could bring the teaching-learning process on track. As a result, teaching-learning activities have surged in virtual tutoring, video conferencing, and online learning platforms. Classes on Google Meet, Zoom App, Google Classroom, WhatsApp, Skype, etc., have become a norm. As per the advancement of recent technology, students worldwide have two challenges: the first is to learn to use the latest technology, and the other is to interact more effectively with one another (Spires et al., 2017).

To go through the online teaching-learning process, internet connection is critically essential. According to a report based on the 2017–18 National Sample Survey, less than 15 per cent of rural and 42 per cent urban Indian households have internet access (Ministry of Statistics & Programme Implementation, 2020). During the COVID-19 pandemic, internet consumption rose dramatically by around 13 per cent in India

(Madhukalya, 2020). Today, 70 per cent of the 15 to 24 years old age population is online (Coward, 2018) and often spend more time online than adults above these age limits (Ofcom, 2019). Therefore, they are more exposed to both benefits and the risks of being connected. Today smartphone is the primary access point for the internet in India. Five hundred million smartphone users were reported at the end of 2019 in India (India Cellular and Electronics Association, 2020). Digital literacy is more important for first-time users to help them become more responsible, employable, and tolerant future citizens (Nascimbeni & Vosloo, 2019). Sudden exposure to digital screens for long hours of attending online classes without prior experience may cause physical and mental stress on students (Gohain, 2020).Children start using digital tools at an early stage. However, this does not mean that they are digitally literate. They still need supporting guidance for developing their critical evaluation skills, information-seeking skills, and collaboratives competencies (Kanchev et al., 2016).

Challenges of Digital Literacy

One of the major challenges that hinder students' digital literacy across the globe is quality of access. Poor-quality technological infrastructure, unavailability of local language content relating to everyday activities disrupts the students' ability to gain digital literacy (Nascimbeni & Vosloo, 2019; Tan et al., 2017). The slow curricular reforms in many countries keep students away from the advantage of being digitally literate (Coward, 2018). Another challenge in enabling the students to be digitally literate is the awareness and support of parents at home. On the one hand, a study by Livingston & Byrne (2015) indicates the need to make parents aware of the potential opportunities which bring their children digitally literate. On the other hand, a study by Mascheroni et al. (2016) highlights the parental expectations of the role of ICT in their child's future. The parental role is grooming and socialising their children to take advantage of the digital literacy toward their growth and development, which goes a long way to make their children future-ready. The study has also highlighted that teachers who use Information and Communication Technology (ICT) in their teaching and schools which invest in the ICT training of their teachers tend to have better digital competencies in their students (Fau & Moreau, 2018). One of the other challenges is the lack of digital literacy being mainstreamed in the school curriculum (Nascimbeni & Vosloo, 2019).

Understanding Digital Literacy in the Current Scenario

Digital literacy can be seen as an umbrella term that includes several sister concepts such as computer literacy, information literacy, 21st-century skills, media, and information literacy. It extends to using digital devices and digital media production, information processing, retrieval, and social network participation to create and share knowledge (Alexander et al., 2016; Karpati, 2011). However, from a pragmatic point of view, digital literacy is the set of skills, knowledge, and attitudes required to access digital information effectively, efficiently, and ethically including how to evaluate digital data and how to use it (Spante et al., 2018).

According to Law et al. (2018), digital literacy is about creating information not only safely but also appropriate. It also includes access, management, understanding, integration, communication, and evaluation using key competencies in computer literacy, ICT literacy, information literacy and media literacy. Similarly, Nascimbeni and Vosloo (2019) also explains digital literacy as having knowledge, skills and attitudes that safely empower children to grow and flourish in the global competitive digital world. Ministry of Electronics and Information Technology (2020) defined digital literacy as individuals' ability to understand and use the basics (terminology, navigation, and functionality) of digital devices. It extends across the ability to use technologies for meaningful actions like-accessing, creating, managing, and sharing information; using the internet and technology to communicate effectively; frequently using the technology in everyday life and executing cashless transactions through digital financial tools, online citizen-centric services, etc. As per the current scenario, digital literacy in education encloses much more than the above concept. For example, students must have skills like the ability to operate digital platforms to attend online classes, create passwords, follow age-appropriate privacy concerns, create, collaborate, share digital content with peers and their teachers and be respectful and responsible online.

Rationale of the Study

We are growing up in a world where digital technologies are universal and indispensable. It propels innovation in education and training practices, improves access to lifelong learning, imparts new digital competencies (Carretero et al., 2017). Karpati (2011) revealed that digital literacy has positive effects on skills essential for successful learning. It helps the students access information more efficiently, manage data, and use it in their private lives. Abdollahyan and Ahmadi (2011) clearly expressed that students who started using the internet earlier and spent more time on web browsing are more familiar with digital literacy. Pratap and Singh (2018) explored that respondents significantly used digital resources daily to update their subject knowledge and advance their thinking skills. Saubari and Baharuddin (2016) explored that students preferably used digital literacy for knowledge-seeking purposes, which can be applied in real life. Rokenes and Krumsvik (2014) pointed in their study that the development of digital literacy depended on the acceptance of new learning methods, collaborative learning, and connecting theories with practice. Ata and Yildirim (2019), in their study, concluded that digital literacy courses should be included in all teacher education programs. They also emphasized practical activities so that they could navigate the digital environment effectively. Similarly, Milenkova, Manov, and Peicheva (2020) found in their study that education and the technological environment play a crucial role in shaping digital skills. They also emphasised giving more effort to improve the educational methods to create digital competencies for learners. Choudhary (2020) pointed out that besides having various problems and hindrances in attending online classes, lack of digital literacy of students was also a major reason due to which only 30 per cent of the students were able to attend online classes. He also suggested urgent policy interventions to promote and ensure digital literacy among the masses for successful online classes.

The analysis of the above research studies shows that majority of the researches were conducted about digital literacies and their impact. However, only a few studies tried to find digital literacies and the challenges students face in attending online classes. Hence, the proposed study of digital literacy as a challenge for students to participate in online classes during the COVID-19 pandemic is imperative in the current scenario.

Research Questions

1. To what extent is digital literacy possessed by students?
2. What are the different kinds of challenges faced by students to attend online classes?
3. What are the different kinds of digital devices being used by students to attend online classes?
4. What are the different digital platforms being used by students for academic activities?

Objectives of the Study

1. To identify digital literacy possessed by students to participate in online classes.
2. To find out the challenges faced by students while participating in online classes.
3. To find out the kinds of digital devices used by students while attending online classes.
4. To find out the different digital platforms used for academic activities to participate in online classes.

Research Method

Since the present research study intends to focus on digital literacy as a challenge for students to participate in online classes during the COVID-19 pandemic, it studies to understand the impact of a non-manipulative variable. In the situation of the COVID-19 pandemic, the descriptive survey method of research was most appropriate for this study (Creswell and Creswell, 2018).

Population and Sample

In this study, all students of classes VII, VIII, and IX studying in Jawahar Navodaya Vidyalaya Jethian, Gaya and D.A.V. Public School, Gaya, India, constituted the population. More than 1000 students are studying in both schools. A representative random sample of 100 students was selected from both schools. Out of 100 students, 59 were boys, and 41 were girls.

Tools and Techniques

1. DigComp 2.0: The Digital Competence Framework for Citizens developed by Vuorikari et al., 2016 was used as a three-point rating scale as a tool to check digital literacy.
2. The self-developed three-point rating scale was used to find out the challenges students face while attending online classes.
3. A self-developed alternative Yes-No scale was used to determine the frequency of use of digital resources and digital platforms used for academic activities to attend online classes.

Data Collection

The data was collected digitally through google forms. All the questionnaires were set in the google form, and the link was sent to the students of respective classes. They were requested to complete the questionnaire within a limited period. Randomly first 100 responses were taken from both the schools. After receiving 100 responses, the option to receive further data was turned off in the goggle form.

Analysis and Findings

Digital literacy competence areas, along with their description, were studied with a rating scale. Respondents were asked to mark their responses with always/sometimes/never. Table 1 gives the analysis of their responses.

Table 1: Digital literacy competence areas, along with a description

Competence Area	Descriptions	Rating Scale			Results (%)
		Always	Sometimes	Never	
Fundamentals of hardware and software	Able to turn on/off the digital devices.	63	35	2	98
	Able to create a user account and password in the devices.	56	33	11	89
Information and data literacy	Able to browse, search filter data and information.	53	43	04	96
	Able to evaluate, manage data, information, and digital content.	16	24	60	40
Communication and collaboration	Able to choose the right tools for the mode of communication.	43	47	10	90
	Able to share and collaborate through digital technologies with their online instructors or their virtual classmates.	44	43	13	87
Digital content creation	Able to develop digital content (text, graphs, images, and multimedia)	10	17	73	27
	Able to integrate or create new information/content.	09	06	85	15

Safety	Able to protect digital devices.	39	56	05	95
	Able to protect personal data and privacy	54	36	10	90
Problem-solving	Able to solve technical problems	28	56	16	84
	Able to creatively using digital technologies	32	51	17	83

Table 1 and Fig. 1 indicate that in the domain of fundamentals of hardware and software competence area, 98 per cent of the students were competent enough to operate their digital devices. Along with this, most of the respondents (89%) of the students were able to create a user account and set a password on their devices.

In another domain of information and data literacy competence area, the majority of the respondents (96%) were competent in browsing, searching, filtering data and information. Still, a significant number of the respondents (60%) were unable to examine the reliability and validity of the data source, information and digital contents.

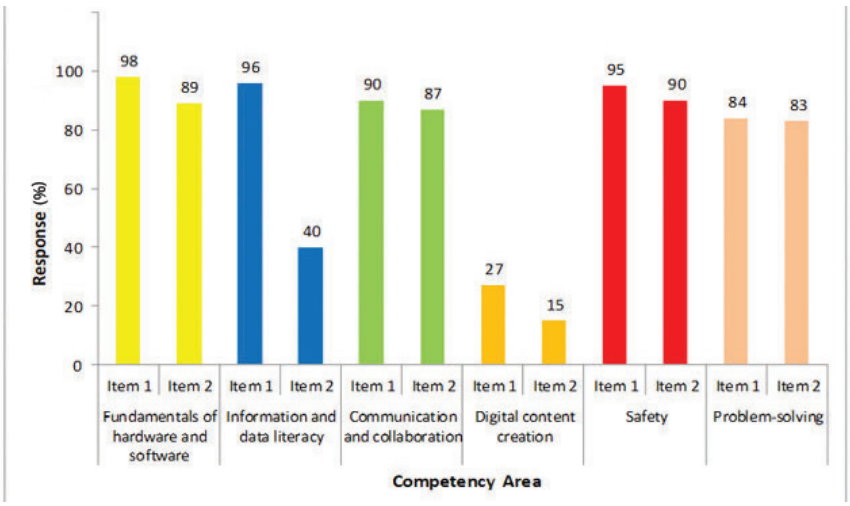

Fig. 1. Graphical presentation of digital literacy competence

In the competence area of communication and collaboration, the majority of the respondents (90%) were competent enough in choosing the right tools for interacting through a variety of digital technologies, and the majority (87%) have the right skills to share and collaborate through digital technologies with their online instructors or their virtual classmates.

In the digital content creation competence area domain, the majority of the respondents (73%) were unable to produce and modify digital content in different formats (text, graphs, images and multimedia). Along with this, most of the respondents (85%) were not competent enough in integrating or creating any content.

In the matter of safety area of competence, the majority of the respondents (95%) were able to protect the digital devices, whereas (80%) students were able to protect their data and privacy.

In the problem-solving subscale of competence area, the majority of the respondents (84%) were able to solve technical problems, and also most of them (83%) had skills and the ability to use digital technology creatively.

Students' challenges to attend online classes were identified with a rating scale that asked them to respond with always/sometimes/ never with the statements. Table 2 gives the analysis of their responses.

Table 2: Challenges faced by students while attending online classes

Item No.	Description of Items	Rating Scale			Results (%)
		Always	Sometimes	Never	
1.	Low internet connectivity (especially for remote places, including cost)	42	48	10	90
2.	Lack of ICT infrastructure	40	41	19	81
3.	Problems with audio and video connectivity	41	52	07	93
4	A large number of classes in a day	49	27	24	76
5.	Unavailability of devices like - android phone, laptop, tablet, computers, etc.,	40	34	26	74
6.	Issues with installation and login problems on online platforms	34	49	17	83
7.	Whether the concept is being cleared	27	56	17	83
8.	Lack of quality content in the local language	32	37	31	69
9.	Lack of teachers' technical capacity	36	43	21	79
10.	Too much screen time cause poor vision, strain, anxiety, and physical problems	49	35	16	84

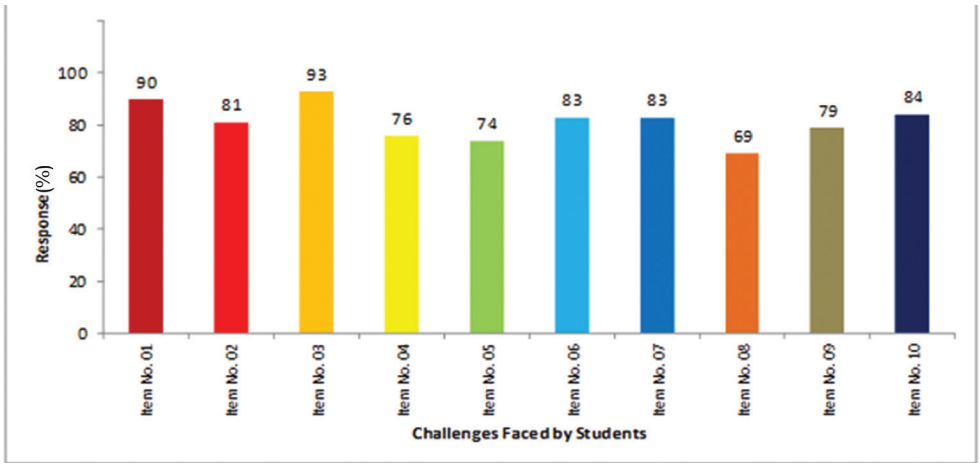

Fig. 2. Graphical presentation of digital literacy competence

As shown in Table 2 and Fig. 2, most of the respondents, 90 per cent, agreed that low internet connectivity (especially for remote places, including cost) and the unavailability of ICT infrastructure were significant challenges faced by them while attending online classes. Another major problem faced by most respondents, 93 per cent, was on issues relative to audio, video connectivity, and 76 per cent had issues with having too many classes in a single day.

To attend online classes, devices like android phones, laptops, tablets, computers, etc., were essential. Seventy-four per cent of the respondents faced problems with the unavailability of these devices. This problem was further compounded by the installation and login issue faced by 83 per cent of respondents.

The majority of the respondents (56%) agreed that the concepts were not being taught clearly. Besides that, the unavailability of quality content in the local language was also a significant challenge in online learning for 69 per cent of the respondents.

Seventy-nine per cent of the respondents agreed that there was a lack of teachers' technical competence. Due to sudden exposure to digital screens for a long hour, 84 per cent of students reported poor vision, strain, anxiety, and physical problems.

Qualitative data collected using open-ended questions were analysed thematically.

Students' responses on challenges to attend the online classes are summaries below based on themes.

Table 3: Theme-wise description of challenges faced by students.

Themes	Description of the themes
Letter-size	Small letters appear on the screen during the online teaching-learning process.
Doubts session	Students rarely get doubt clearing sessions during online classes.

Time management system	Classes were set as per the teachers' choice and ignoring student's convenience.
Practical session	There was no provision of the practical session for the science classes.
Digital Devices	There was always a lack of availability of digital devices at home.

Availability of digital devices used for academic activities has been identified with an alternative scale which asked them to respond with Yes/No. Table 4 maps out their responses.

Table 4: Availability of digital devices to attend online classes

Sl. No.	Digital devices	Yes	No
1.	Smart phone	96	04
2.	Laptop	45	55
3.	Desktop	10	90
4.	Tablet	12	88

Table No. 4 indicates that 96 per cent of the students had a smartphone, 45 per cent had a laptop, 12 per cent had a tablet and only 10 per cent had desktop to be used for academic activities.

Data regarding the availability of digital platforms used for academic activities were identified with an alternative scale Yes /No response. Table 5 gives the analysis of their responses.

Table 5: Digital platforms used during online classes

Sl. No.	Digital Platforms	Yes(%)	No (%)
1.	Google Meet	59	41
2.	Google Classroom	25	75
3.	Zoom	66	34
4.	WhatsApp	68	32
5.	Skype	13	87
6.	Teams	08	91
7.	WeChat Work	07	93
8.	Hangouts Meet	08	92
9.	Ding talk	07	93
10.	Lark	03	97

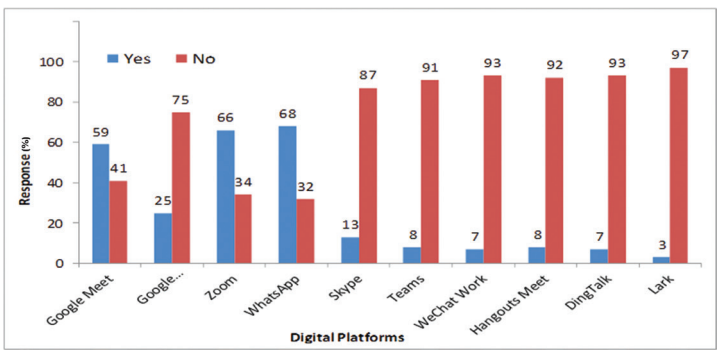

Fig. 3: Graphical presentation of different digital platforms used during online classes

Table 5 and Fig. 3 indicate that different digital platforms were being used for academic activities, where WhatsApp usage was at 68 per cent, Zoom at 66 per cent, Google Meet at 59 per cent, and Google Classroom at 25 per cent. Similarly, other digital platforms like Skype, Teams, We Chat Work, Hangouts, Ding Talk, and Lark were 13 per cent, 8 per cent, 7 per cent, 8 per cent, 7 per cent and 3 per cent, respectively.

From the above discussion, it can be concluded that digital platforms like Google Meet, Zoom, and WhatsApp were frequently used to organise online classes for the teaching-learning process.

Discussion of the Results

In this student-oriented study, it has been established from our results and analysis that the majority of the students had digital literacy in the competence areas like fundamentals of hardware and software, communication and collaboration, safety, problem-solving, but they were less competent in the area of data evaluation and management, information and digital contents. Along with this, most were less competent in digital content creation, which comprised developing digital content (text, graphs, images and multimedia) and integrating and creating new content.

However, attending online learning systems exposed students to many challenges. The main difficulties identified were the unavailability of devices like android phone, laptop, tablet, computers, etc. They also had issues with installation and login problems on online platforms, low internet connectivity interfering with audio and video connectivity. Another fundamental barrier was the lack of teachers' technical competencies because they were trained to a teaching process in a physical setting. The sudden switching of teaching to an online portal gave teachers no time to equip themselves. Online learning required quality content materials that were designed specifically for the virtual learning environment. A huge gap arose between the demand for digital competency from the teachers and their skills level. Besides, sudden exposure to digital screens for long hours with no standard practical practice leads to poor vision, strain, anxiety and physical problems among the students. The findings were inconsistent with the report shared by (Hassinger-Das et al., 2020; Gohain, 2020). It is also found that smartphones were the most critical digital devices used by most students to attend their online classes. This finding of the current study supports and is aligned with the findings of a study conducted by Rajasekhar and Jaishree (2020) that the mobile phone or the smartphone was an essential device used as a necessary education tool. Google Meet, Zoom, WhatsApp have become the digital collaborative platforms used by most of the respondents for learning requirements.

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ROLE OF SCIENTIFIC LITERACY IN ERADICATING SUPERSTITIOUS BELIEFS DURING COVID-19 PANDEMIC

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COVID-19 is categorized as one of the most serious respiratory diseases caused by novel coronavirus. Since its first appearance in China in December 2019 as an epidemic, the disease spread rapidly across the globe, and within few months, it became a pandemic. Due to its contagious nature and non-availability of precise therapy, many people are considering it as evil. Limited public awareness about the virus structure, its life-cycle, mode of transmission and action, diagnostic strategies, therapy, etc., is fueling such people's mindset to live with their own beliefs about the disease. Lack of proper scientific knowledge about COVID-19 prompts to nurture various myths, misbeliefs, and superstitions among people. Seeding scientific temperament and awareness based on scientific knowledge is the only way to overcome such a situation. The main focus of the study is to understand the mechanism of developed misbeliefs and superstitions among people during the COVID-19 pandemic, the merits of a scientifically literate person as an informed citizen during the current pandemic, and the role of scientific literacy at the time of COVID-19 crisis.

Keywords: Scientific literacy, superstitious beliefs, myths.

Introduction

COVID-19 crisis developed a truly global challenge, and the challenge is enormous. Our physical, social and natural environment changed due to this COVID-19 pandemic. COVID-19 has affected every part of human life across the globe including all academic activities (Sahu, 2020). It rapidly spread worldwide, posing its unintended outcomes related to health, environment, education and causing unprecedented socio-economic disturbances. Apart from this, lots of misbeliefs and superstitions have also risen during this pandemic, "On one hand, the severe outbreak of a pandemic disease of Novel Coronavirus is washing away the world's economy, and on the other hand, the Indians has triggered the surge of several superstitions to fight back with it" (Sharma, 2020). This shows that the coronavirus outbreak has severe repercussions and comes out as a global challenge. Hence, "it is vitally important that we understand the science of our new realities and have an informed citizenry. Never before in modern times have we seen such an overwhelming demonstration of the need for science & literacy" (Sinclair, Parker & Dunkelberger, 2020). Hundreds and thousands of misbeliefs and superstitions related to the COVID-19 pandemic have been found in our country's people. "A sea of misinformation and fake news has been generated over the pandemic; in particular, social media has been rife with misbeliefs and superstitions galore" (Dutta, 2020). All the misinformation spread by the non-reliable sources related to the pandemic can be prevented if we become informed citizens and take all the precautions as per

the state and central government guidelines. In this respect, the public level of scientific understanding and knowledge, and trust in science and reason, can play an important role in critically analyzing all the information conveyed by social media and other sources about the COVID-19 pandemic.

Superstitious beliefs and COVID-19 disease

Superstitious beliefs: It is believing blindly in something without verification (Kalita, 2016). It might be a product of a lack of confidence in oneself and the world of science and logic.

Dutta (2020) listed the following as agencies through which superstitions and misbeliefs about COVID19 have gone viral in India:

1. New digitally literate people, who cannot cross-check fake information, and blindly believe in forwarded messages that are going viral have been circulating misinformation about COVID-19.
2. Social media is used as a primary carrier for disseminating superstitions about COVID-19.
3. People who intend to help their loved ones and not to harm those forward illogical messages.
4. For money making 'homo digitalis' involved in spreading misbeliefs regarding COVID-19.
5. Prosumers are another category who feel pleasure by spreading misbeliefs regarding COVID-19.

Several superstitions and misbeliefs originated during the pandemic crisis such as:

1. Cow dung and urine can help cure the virus elimination.
2. The water of the holy river Ganga can be used to protect people from coronavirus infection.
3. Spraying alcohol or chlorine all over the body kills the new coronavirus (Naeem & Bhatia, 2020).
4. Taking non-vegetarian food is harmful in such a situation.
5. Eating garlic and drinking alcohol can prevent virus infection.
6. Taking hot water with lemon prevents virus infection.
7. Gargling, a cure for COVID-19 as the virus remains in the throat for four days (Sharma et al., 2020).
8. Sesame oil is used to block the virus from entering our body (Sharma et al., 2020).
9. Mosquitoes are vectors of coronavirus.
10. Tying one leg with red thread to avoid corona.
11. Indians have better immunity than others against coronavirus.
12. Different rituals are performed by the different communities, like lighting an earthen lamp, each per sibling or placing coconut shells with neem outside the village.
13. Coronavirus cannot survive in hot temperatures.
14. Only people with symptoms of COVID-19 can spread the disease, but the fact is that people having virus

infection, but without symptoms can also spread the disease.

15. Prime Minister Narendra Modi's initiative to show gratitude towards coronavirus warriors by clapping and clanging utensils, and by turning off lights for 9 minutes at 9 pm on 5th April and again lighting a candle, earthen lamp, mobile flashlight, torch, bulb, etc., were misinterpreted as measures to ward off the virus.

Scientific literacy and COVID-19 disease

Scientific Literacy: OECD/ PISA defined scientific literacy as "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and make decisions about the natural world and the changes made to it through human activity" (Gillbert, 2004).

A scientifically literate person has the following abilities:

1. He/she thinks logically.
2. He/she can seek answers to questions generated from everyday experiences.
3. He/she always analyze local, national, international, global issues and, in turn, makes informed decisions.
4. He/she evaluates the truthfulness of any information and data based on sources of information.
5. He/she has faith in science; that is why he/she can predict, analyse, describe, and explain a phenomenon rationally.

Various measures provided by scientific knowledge to fight against the menace of COVID-19 Pandemic

1. Prevention: The only formula for slowing the virus is preventing its spread.
2. Lockdown: To prevent the spread of infection by breaking the chain of transmission.
3. Physical distancing: Staying at a distance of 6 feet from others, avoiding physical contacts like handshakes, hugs, etc.
4. Using a protective face mask: Covering mouth and nose with a protective mask.
5. Good hygiene: Washing hands regularly with soap and water or using hand sanitizer, wiping home surfaces, doors, knobs, cellphones with disinfectants, not touching table tops, chairs, door handles, railing, etc.
6. Quarantine: 14 days of quarantine for someone who has been exposed to the disease, or he/she may have the disease, but symptoms are not showing.
7. Isolation: A person having COVID-19 symptoms and has been tested positive should isolate himself.
8. Monitoring symptoms: Symptoms like fever, dry cough, breathing difficulty should be monitored daily.
9. Ban of spitting in public places as it can spread COVID-19.
10. Stay at home as much as possible.

Qualities of scientifically literate person as an informed citizen during COVID-19 pandemic

- A scientifically literate person is always curious to know about coronavirus disease, including its nature, contagious effect, transmission process, and preventive measures from its transmission.
- Stays up-to-date with various information regarding COVID-19 given by authentic sources like Ministry of Health and Family Welfare, Government of India, WHO, etc.
- Communicates and shares the right information about COVID-19 disease to relatives, peers, caregivers, and others.
- Evaluates the quality of information/ facts about COVID-19 that social media or other sources may disseminate and then interprets and categorized information as valid information or misbelief or superstition or false fact.
- Acts per guidelines recommended by the health ministry or designated higher authorities about COVID-19.
- He/she is aware of the present and future consequences of unnecessary information related to COVID-19 in the form of misbeliefs and superstitions.
- Follows preventive measures against COVID-19 announced by the government.
- He/she checks the source of information before sharing or forwarding it.
- By understanding the consequences of their actions during a pandemic, a scientifically literate person not only helps himself/herself but others also.

Role of scientific literacy in eradicating superstitions and misbeliefs at the time of COVID-19 pandemic

In the present situation of pandemic, people have also developed countless misbeliefs and unscientific superstitions (Sharma, 2020). "As rapidly as the virus has spread, misin-formation has spread faster" (Sinclair, Parker & Dunkelderger, 2020). In the form of rumors, misinformation, misbeliefs, and superstitions about COVID-19, particularly regarding its risk to the public, leads to greater uncertainty and fear. Fighting with misbeliefs, superstitions, or false information along with COVID-19 disease is the new front in the COVID-19 battle. We can fight with this "by fact-checking, listening to credible experts, and dispelling and debunking alternative theories, dangerous cure, and myths" (Sinclair, Parker & Dunkelderger, 2020). Scientific literacy needs to develop during this pandemic crisis, because instead of misbeliefs and superstitions, it is the only correct strategy that provides us the right path based on reason to fight this pandemic problem. Scientific literacy provides us a context for addressing societal problems, and a science-literate populace can better cope with many of its problems and make intelligent and informed decisions that will affect the quality of their lives (Zen, 2018). The scientifically literate person can effectively use all these processes for solving the various related issues/challenges of life being impacted by pandemics. One of the key issues with this "invisible disaster" is obtaining correct information about it through

various sources. WHO Director General Ghebreyesus said "we are not just fighting an epidemic; we are fighting an Infodemic" (Hua & Shaw, 2020). Experts and researchers from diverse scientific backgrounds are continuously studying and doing their best to know more about the virus so that people can easily remove the misinformation, rumors, misbeliefs, superstitions, etc., to health and other issues during the pandemic. Scientific literacy brings scientific understanding in people, and with this understanding, they can address societal issues with a scientific mindset free from misbeliefs, superstitions, misinformation, etc. In this respect, the World Economic Forum had published a three-step guideline on how to read news like scientists and avoid the COVID-19 Infodemic, which included: (i) embracing uncertainty responsibly, (ii) asking where is the information coming from, and (iii) determining who is backing up the claim" (Naem & Bhatti, 2020). The above three are qualities of a scientifically literate person because a scientifically literate person asks, finds or determines answers to questions about everyday experiences. Therefore, it is important that with the ongoing pandemic, if people are more exposed to science-based information, scientific knowledge, and scientific community more, they can know about the nature of COVID-19 disease and be able to discard the misbeliefs and superstitions about it.

Conclusion

The growing issues of COVID-19 at the global, national, and local levels impact our lives, and it demands an insight into scientific knowledge. The process by which the scientifically literate community acquires the scientific knowledge to cope with issues like the COVID-19 pandemic includes observation, hypothesis formation, experimentation, analysis and interpretation. The scientifically literate person can effectively use all these processes for solving the various related issues/challenges of life that the pandemic impacts. One of the key issues of the "invisible disaster" is obtaining correct information. WHO's Director-General Ghebreyesus had warned of the threat of an "infodemic" — an over abundance of information, some of which can be misleading or even harmful. People also have misinformation, myths, rumors, false facts, misbeliefs, etc. (Hua and Shaw, 2020). At the rate at which coronavirus has spread around us, with the same rate, various customied information, including rumors, fake news, false fact, misbeliefs, superstition by some specific group of people, are also disseminated. COVID-19 has social, economic, psychological, and health impact. But we now have to protect ourselves not only from the pandemic but also from misinformation, myths, superstitions, etc. Therefore, there is a strong need for scientific understanding because a scientifically literate person, before believing and sharing such information, tests the authenticity of the information. Surely, COVID-19 pandemic has brought to our attention how building up scientific temperament and propagation of scientific literate culture are critically important to tackling a pandemic of this scale (Biswas, 2020).

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ONLINE SCIENCE TEACHING AND LEARNING AMONG CHILDREN DURING COVID-19 PANDEMIC

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The paper examines the situation and emerging crisis in the pandemic and the condition of school education with special reference to science education. Continuing the education of students emerged as a major challenge during the unprecedented lockdown. Digital learning is a terrain which was not widely explored by the teachers for classroom teaching. The education sector in India is one important area that has been severely affected by the lockdown and the imposed restrictions. The study was conducted with 500 science teachers from 9 states on various pertinent points including awareness, preparedness mode, methods used teaching, usage of apps, managing-interactions, assignments and assessments during the COVID-19 pandemic.

Keywords: Digital learning, online science teaching and learning, science teachers.

Introduction

Planet Earth has witnessed many epidemics in the past centuries. From the dark ages, we have come such a long way, that we now have ways to combat such deadly diseases. The pandemics also affect the socio-cultural dynamics of the society, even long after they are eradicated. The year 2020 saw the advent of an unprecedented pandemic — COVID-19 caused by a novel coronavirus.

History of pandemics in the world

In the history of the world, there have been many infectious diseases that have claimed the lives of millions of people. The Great Plague was the major epidemic of the bubonic plague in England, which lasted from 1665 to 1666. Another plague, which was caused by the *Yersinia pestis* bacterium, killed an estimated 100,000 people. Tuberculosis (TB) caused by *Mycobacterium tuberculosis* is responsible for approximately 1 million human deaths every year (World Health Organization 2020a). This disease took a death toll of millions before antibiotic streptomycin was discovered in 1943. Swine Flu Pandemic in the USA in 1976–1977, also commonly called influenza infected about 500 million people with a mortality rate of about 10 per cent.

Currently, all the countries across the world are under the fatal clutches of COVID-19. The first cluster of cases was formally reported in Wuhan City, China, on 31 December 2019.

WHO became aware of 282 confirmed cases across the Asian continent. The cause of the severe acute respiratory syndrome that became known as COVID-19 was a novel coronavirus, SARS-CoV-2. The virus was isolated on 07 January, and its genome was shared on 12 January 2020.

The world transformed in the blink of an eye. The virus spread faster than anticipated. 2.45

million people had been reported dead from the coronavirus COVID-19 outbreak as of 07 August 2020. The number of recorded deaths in India due to coronavirus have been 1,56,212 as of February 20, 2021 (Ministry of Health and Family Welfare, GoI).

COVID 19 pandemic in India

India was also not spared. With its first confirmed case reported in Kerala, in a student returning from Wuhan, the Government of India sprung into action. The Prime Minister of India urged all people to stay at home except those in essential services, calling for 'Janata curfew' on 22 March from 7 AM–9 PM. With the success of this endeavor and the escalating spread of this virus, the PM of the nation declared countrywide lockdown for 21 days with effect from 25 March 2020, in the exercise of the powers under section 6(2)(i) of the Disaster Management Act, 2005.

COVID-19 pandemic and school education in India

Due to the nation-wide lockdown, all educational institutions were closed. All national and state-level examinations were also postponed, keeping in mind the safety of the students. Students were now confined to the safety of their homes. However, despite the best efforts of the government, the people, and the agencies, the virus spread fast. Although the curve was significantly dampened, the number of positive cases kept increasing. The lives of the citizens, could not be put at stake. At this crucial juncture, the lockdown was further extended.

According to the 2020 Global Education Monitoring Report (UNESCO), almost 91 per cent of students worldwide were out of school during school closures in April 2020. Students were deprived of any regular curricular activity for close to 2 months during the lockdown period. They were also getting restless without social interaction and physical activity (games and sports). Keeping them occupied at home posed a challenge for the parents. The parents working from home already had a lot on their shoulders with businesses downsizing, handling child development and addressing their educational needs became a big issue.

All the institutions switched to online classes under the directives of MHRD. The transition from a conventional classroom to a digital one was an uphill battle for all the stakeholders — the administration, the teachers, the students, and the parents. The digital infrastructure was not in place to completely support teaching-learning. Not all institutions were equipped for this transformation on such short notice. The majority of teachers' preparedness in these digital mediums was limited compared to the need of the hour (Sinha, 2020a; Sinha, 2020b).

Importance of Science

Science is one of the most important subjects. It is a universal fact that it enables the students to develop problem-solving and critical thinking skills. Science education enables students to generate ideas, intelligently take decisions, analyse events and phenomenon, and derive conclusions. The implications of these skills is lifelong. Science needs to be taught and learned as a sport for the brain.

The nature of Science is to investigate through experiences and then logically infer and

explain the data collected. In a conventional classroom before the COVID-19 pandemic,

science teaching was supplemented by experiments, observations, hands-on activities. Teaching science pedagogy involves activities in groups, discussions with classmates and teachers, surveys, organization and data analysis. Display of models and project work through exhibitions, etc., in schools and neighborhoods, were an important component of pedagogy (NCF, 2005). National Curriculum Framework (NCF) 2005 proposed activity-based teaching as a paradigm shift for science learning. Laboratories and outdoor activities are inseparable from science teaching and learning. Due to the current pandemic, all such activities came to a halt. With students and teachers confined in their homes, it was difficult to perform activities and experiments.

Most school teaching in COVID-19 times is being carried out online or via other modes of distance learning. The teachers resorted to various digital platforms to facilitate the process of teaching-learning. Classes were being conducted on Zoom, Google Meet, and WebX. WhatsApp and Telegram messages in a group became the new digital noticeboard. Assignments were given and submitted on google forms or drive. Assessment sheets were circulated as images on various platforms or as emails to the parents. Feedback was not instantaneous as rapid switch-over did not leave any room for teachers to evaluate while getting accustomed to teaching through digital mediums (Sinha, 2020a; Sinha, 2020b).

Subjects with less dependency on the laboratories and experimentations were quick to adapt to the situations. Although subjects like law and languages lost the flavor of their regular activities like moot courts, debates, discussions, and brainstorming sessions, they still had the upper hand over subjects like Science that involve demonstration and experimentation.

The author conducted a quick survey to determine how science teaching is being carried out in schools in the lockdown period. A total number of 500 science teachers from Delhi, Haryana, Chandigarh, Chhattisgarh, Bihar, Tamil Nadu, Madhya Pradesh, and Uttar Pradesh participated in the survey.

Results and Disscussion

Based on responses received, the following picture about science teaching in these States/UTs emerged :

1. Use of digital mediums/platforms for teaching

100 per cent of the participating teachers (both government and private) carried out Science teaching using various digital mediums.

2. Ease of adaptation of digital mediums/ platforms for teaching

Even though the implementation of online teaching was done hurriedly with little time to plan, only 1/3rd of the participant teachers could adapt to the online mode of teaching science effortlessly.

3. Types of digital platforms used

While some of the teachers relied on free digital platforms to conduct online classes, viz., Google Meet, Zoom, and Webex, most of them (60%) also used other mediums that were a part of their learning management systems (Fig. 1).

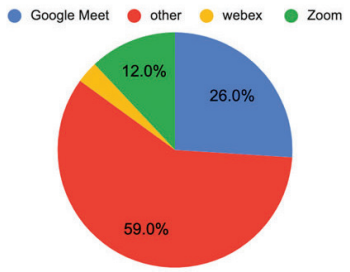

Fig. 1. Type of digital platform used in conducting online classes

4. Mode of digital communication used.

To communicate with students and parents, science teachers heavily relied on WhatsApp audio, text, and video messages. Communication through the emails was the least used method. Teachers in private schools used already existing Learning Management Systems for communication. In remote places, with network-data issues, teachers used the phone call as the primary communication mode (Fig. 2).

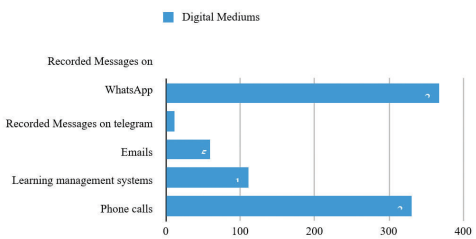

Fig. 2. Use of various digital mediums

The digital mediums that became inevitable due to the pandemic conditions were seldom used before by the whopping majority of science teachers.

5. Preparedness for using digital mediums

The teaching fraternity was caught unawares by the magnitude of the pandemic and the duration of lockdown. 368 out of the 500 participating teachers taught themselves to use digital mediums and devices for conducting online classes by looking at various videos online. Teachers, mainly from private schools, had multiple training programmes to aid them in this transformation.

6. Time spent on preparation of lessons

Since this paradigm shift from face-to-face to online class completely was unprecedented, teachers had to devote double the time than usual to prepare for their online classes.

7. Methods of demonstrating science experiments

80 per cent of the respondents relied on YouTube videos for demonstrating science experiments.

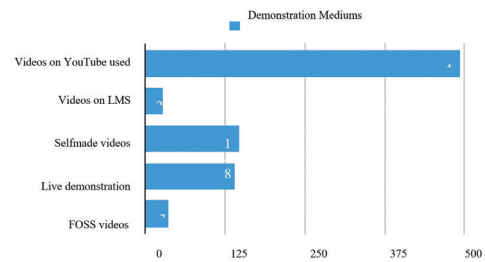

Fig. 3. Methods used in demonstrating Science

Science experiments were done live on the online streams with whatever means were available to them while using YouTube videos as a reference. 148 teachers out of 500 participants took the initiative to record their videos and sent them to students for reference (Fig. 3).

8. Use of advanced science-related apps

Teachers in Chandigarh and Delhi used augmented reality apps to supplement their science teaching. 25 per cent of the participating teachers relied on online simulation of laboratory experiments.

Teaching with the help of new software that is specifically made for science topics was an unknown phenomenon. None of the teachers mentioned any specific software for this purpose.

Teachers also mentioned that to supplement their teaching, they accessed various platforms/apps viz., Coggle (Mind maps and flow charts), Padlet, PhET (interactive simulations), Olabs, Edpuzzle (interactive video lessons), Nearpod (interactive lesson), and pixel lab.

9. Responding to the queries and doubts

To address students' queries, the participating teachers used WhatsApp and telegrams texts, audio notes, and short video clips. Email was the least used medium. A lot of them resolved student's doubts during the online class itself. Few teachers conducted separate sessions for answering students' problems, as shown in Fig. 4.

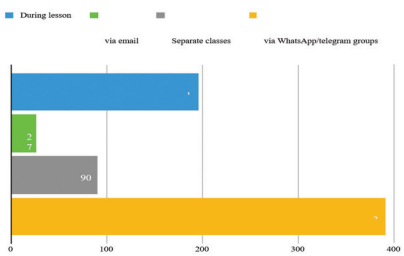

Fig. 4. Dealing with queries and doubts of students

10. Mode of collecting assignments

Many teachers, especially in remote areas, used WhatsApp and telegram to send and receive student's assignments. Participants of private schools relied on their Learning Management Systems (LMS) wherever available, while some resorted to using Google Drive, as depicted in Fig. 5.

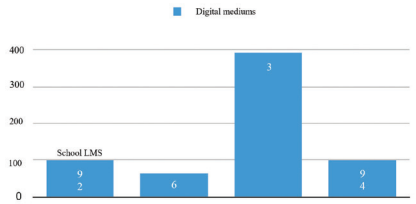

Fig. 5. Mode of collecting assignments

11. Assessment

Assessment is an important part of teaching-learning. Assignments were given to the student from time to time. It will be difficult to assess the students during online lessons as the teachers themselves face issues in digital classrooms. Assessing students digitally is a challenge as compared to that in conventional classrooms. For the collection/ submission of assignments, various mediums were used. Most of them circulated and collected questions and exercises through Whatsapp/Telegram groups. Assessment questions, quizzes, and assignments were given and collected through School Learning Management Systems (LMS) by a considerable number of teachers (Fig. 6). Most of the teachers graded the students on the assignments that were submitted.

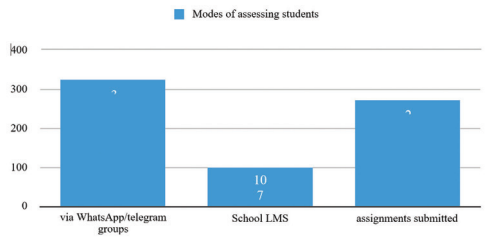

Fig. 6. Modes of assessing student

12. Online vs. Conventional classroom teaching

Surprisingly, 6 per cent of teacher participants felt that online teaching of Science was a better experience than classroom teaching.

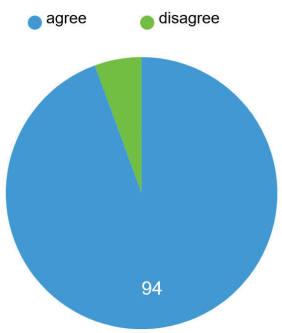

Fig. 7. Online teaching vs. conventional classroom teaching

13. Awareness about existing digital initiatives by the government

The GOI had started the Swayam Prabha Channel to promote digital initiatives. SWAYAM Prabha is an initiative to provide 32 High-Quality Educational Channels through DTH (Direct to Home) across the length and breadth of the country on a 24X7 basis. It has curriculum-based course content covering diverse disciplines. The channels cover both school education (classes I to XII) and higher education. 30 per cent of the participants were not aware of this initiative. 60 per cent viewed the programmes broadcasted and found them useful, while the remaining 10 per cent did not use them as a resource.

The alternative academic calendar prepared by NCERT was followed by the majority of the participants (72%).

Issues while teaching Science during times of COVID-19

Without thorough training, using multiple digital mediums posed a big challenge for teachers. Several issues were shared by the teachers. In the absence of face-to-face peer interaction, at times, teachers found themselves at their wit's end. They could also not mentor each other since all their time was consumed in preparing for their online classes. The teachers struggling with their devices and digital mediums resorted to using their personal devices for conducting classes, the devices which might not have been updated. They spent money personally to buy updated devices for these classes. Teachers also faced difficulty in assessing students online. While recording videos for e-content, teachers struggled with various software to edit, add text, screen record and mix images. Teachers who were able to adapt to this online teaching mode faced an issue dealing with more than 60 students at a time in a single online class. To add to their woes, the parents constantly monitored and gave feedback, which made their work all the more difficult. Many network issues cropped up, which interrupted the smooth conduct of classes. Meanwhile, no digital devices at the disposal of many students were also a cause of the interruption. The usual interaction

which takes place face-to-face was missing in a virtual classroom, which also led to students being inattentive. The increase in screen time of students was a cause of concern for everyone.

The majority of teachers learnt these skills online with the limited resources at their disposal. They felt that they need to be trained thoroughly in developing e-content and skills associated with them.

Moreover, giving lessons online also needs practice and confidence. The non-availability of digital platforms in regional languages put them on a back-foot.

Pandemic amplified educational inequities

While efforts were made in every area so that learning can go on, a huge chunk of students from the deprived and marginalised section of the societies missed these opportunities.

1. Differently-abled children either missed or were not able to access the popular mediums.
2. Economically weaker sections were doubly hit. They lost their livelihoods. Sustaining every day was a problem. Adding to their woes, procuring devices and data networks for children was beyond their means.
3. The children of migrant workers missed the online learning opportunities as they migrated across various cities to their native places.
4. It brought forth diverse affective/ emotional responses to the lives of the stakeholders.
5. The importance and dire need for family and peer support to provide safe and supportive learning spaces were felt deeply.

Where do we go from here?

COVID-19 is here to stay longer than we expected. Each adversity has its upside, though. There is no way to divorce our response to this pandemic from this realization. Reopening of school shortly is still doubtful. Online learning which emerged as a stop-gap arrangement, can no longer be dismissed. Teachers need to explore ways and come to terms with this reality. The sooner, the better.

Based on the findings of the study, the following solutions are suggested for the future of classroom teaching in Science:

1. After the reopening of schools, future science classrooms may be a blended one — digital and conventional.
2. The teachers will have to integrate Information and Communication Technology (ICT) regularly in their classrooms.
3. Teachers need to be periodically trained to upgrade their digital skills.
4. Efficient and cost-effective learning management systems need to be in place in all institutions.
5. Formulating methods to facilitate online assessment on a large scale should be made a priority.
6. Awareness and usage of software specifically made for Science should be

a part of Teacher training, both pre-service and in-service.

7. During internships, the pupil-teachers must conduct classes in blended mode.
8. Availability of cost-effective digital platforms in regional languages should be a priority.
9. The hurried stop-gap responses now need to be thoughtfully built into cost-effective, robust technology solutions that can be scaled up.
10. The rapid advent of COVID-19 triggered the pervasive use of online learning. We have catapulted five years ahead of our present expectations for the usage of technology. The momentum need to be carried forward.

Scientifically and technologically literate citizens would contribute better to understand and effectively deal with the pandemic at multiple levels. As of date, the schools have started reopening with limited attendance, opting for both offline and online modes. The lockdown period has allowed the teachers to bring out their creative talent, be patient while using technology, and better understand the dynamics of continuous change in teaching-learning.

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AN INTRODUCTION TO IMMUNE SYSTEM WITH SPECIAL FOCUS ON VACCINES FOR SARS-COV-2: PART I

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COVID-19, the deadly pandemic caused by the coronavirus, SARS-CoV-2 hit the world hard but at the same time brought out the never-seen-before capabilities and capacities of the scientific community, the manufacturing companies and other stakeholders as the world engaged in its search for a vaccine to subdue the virus. Keeping the nature of COVID-19 pandemic and its impact on the immune system in view, this paper, the first part of the two-part article, attempts to provide a broad idea on a the various aspects related to immune system such as what pathogens do to our body and how our immune system works. The sequence of events that happens during SARS-CoV-2 will also be discussed in brief.

Keywords: Immune system, pathogens, SARS-CoV-2, vaccine.

Introduction

Vaccines are a symbol of triumph of the scientific community's indomitable spirit against nature's vicissitudes and vagaries. Since the first dose of vaccine administered by Edward Jenner, millions of lives have been saved by numerous vaccines at different times. For example, smallpox vaccine in the early 1800s, followed by tetanus, diphtheria pertussis vaccines, polio, measles, rubella, mumps, and more recently hepatitis B, rotavirus vaccine, etc. However, it is during the current COVID-19 pandemic caused by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus 2) that we saw science and technology exploited and used like never before. We saw an extraordinary effort invested by the global scientific community backed by various philanthropists, investors, governments, etc. As a result, in just thirteen months after the identification of the SARS-CoV-2 virus and its genome, several vaccine initiatives have led to the development of over 300 vaccine projects. As of writing this paper, 175.3 million vaccine doses have already been administered using 11 approved vaccines. Nine more are in phase III clinical trials (Ref. 4). Theoretical and technical platforms that have been explored for this vaccine are diverse and innovative; new ones have been approved for the first time in history, changing the world of vaccines once and for all. As for COVID-19, most of the vaccines developed aim to induce neutralizing antibodies against the spike protein (antigen of the SARS-CoV-2). That is, vaccination causes the production of neutralising antibodies which bind to the spike protein of the virus and thereby blocking it from attaching to other cells and preventing it from causing infection. However, the vaccines developed for different diseases

do not respond in the same way. How they are developed and how they act in the body is different for different diseases. But one underlying principle that is common in all of the vaccines is that they are administered so as to provide us immunity from particular diseases caused by pathogens or infectious agents. It is, therefore, imperative to understand how our immune system works in general and the role of vaccines in immunity.

In this article, which is part I of the two-part article, focus will be on what pathogens do to our body and how our immune system responds in general.

Pathogens — the Infectious Agents

A pathogen is simply an infectious agent, also referred to as germ. These disease-causing organisms are all around us. They could be virus, bacterium, protozoan, prion, viroid, or fungus. There are several pathways through which pathogens can invade hosts to survive and thrive. Hosts could be plants, animals, humans and ironically bacteria themselves could sometimes be the host. Transmission of pathogens occurs through many different routes, including air, water, direct and indirect contact, sexual contact, through breast milk, blood, and other body fluids. So why exactly are these harmful? These pathogens are tiny little vehicles that carry instructions on how to make more of themselves. To reproduce, they smuggle this instruction into the host's cells and force the host's cellular mechanism to make more and more of themselves. They spread through the body and hijack more cells, damaging them in the process, which eventually makes us sick to the extent that a person might die. But we are not defenseless; we have our immune system. While other hosts like plants and animals also have developed mechanisms to defeat these pathogens, the human body's immune response is investigated and understood in much detail. The intelligence that is functioning at the micro-level in the human body is something phenomenal and miraculous.

How does our Immune System Work?

Each pathogen is made up of several subparts or molecules, which are unique to that specific pathogen. The subpart, typically proteins, that is immediately recognized as foreign and, as a result, triggers immune response is called an antigen. Immune response is gradual and happens in stages. It can be broadly grouped into two — the Innate Immune Response and the Adaptive (Acquired) Immune Response.

Innate Immune Response

The first line of defense always is innate immune response. The innate immune system is made of defenses against infection that can be activated immediately once a pathogen attacks. The innate immune system is always general or non-specific, meaning anything identified as foreign or non-self is a target for the innate immune response and it has the same mechanism for all pathogens. Essentially made up of barriers, it aims to keep viruses, bacteria, parasites out of our body or limit their ability to spread and move throughout the body. Immune response can also be triggered by foreign particles like dust and other irritants. Skin, tears, sweat, saliva, mucus and cilia

(hair-like projections) that move debris away from the lungs, the gastrointestinal tract, the respiratory tract, the nasopharynx, eyelashes, and other body hair, all work as a physical barrier. If the pathogen breaches this barrier, it prompts general immune responses such as inflammation, complement (a collective term that describes a system of about 20 proteins), etc. The inflammatory response actively brings immune cells to the site of an infection by increasing blood flow to the area. Complement is an important component of innate immune response as it defends our body against the antigens through opsonization, chemotaxis and by activating phagocytic cells or phagocytes, a type of leukocyte (White Blood Cells) that engulf and destroy pathogens through a process called phagocytosis (Hall, 2016). The macrophage is an example of phagocytes. They are also antigen presenting cells. Another type of cell involved is dendritic cells. These do not directly kill pathogens but form a bridge between the innate and adaptive immune systems, meaning that these cells pass information relevant for the adaptive immune response to kick in.

Adaptive Immune Response

Since innate immunity is general and non-specific, it may fail to defeat the pathogen; that's when adaptive immunity (also called acquired immunity), which is much more specific to the invading pathogen, comes into play. The adaptive or acquired immune response takes much longer, sometimes days and even weeks to become established if the system has encountered the pathogen for the first time. However, if the system encounters the same pathogen again, it will mount an immediate and quick response. The adaptive immune response activates when the innate response insufficiently controls an infection. In fact, without information from the innate immune system, the adaptive immune response cannot be mobilized.

There are two major types of Adaptive immunity: Humoral Immunity (HI) and Cell-mediated Immunity (CMI). These processes involve the activities of T and B lymphocytes, another category of leukocytes besides phagocytes. Whether an immature lymphocyte becomes a B cell or T cell simply depends on where in the body it matures. Those lymphocytes that remain in the bone marrow to mature are coined as B Cells ("B" comes from Bursa of Fabricius, a sac-like structure in birds whose only function is production and maturation of B cells). In contrast, those lymphocytes that move and mature in the thymus are coined T cells (Hence the name "T" for Thymus). The maturation of T or B cells involves becoming immunocompetent, meaning that they can bind to the specific antigen on the pathogen. This recognition which is fundamental to the functioning of the adaptive immune response, results from the presence of highly specific receptors on the surface of B and T cells. Receptors are unique chemical structures composed of proteins found on the cell membrane that is capable of binding to specific antigen (LibreTexts, 2021). B lymphocytes or B cells have on the surface of its cell membrane about 1,00,000 antibody molecules that will react highly specifically with only one specific type of antigen. Therefore, when the appropriate antigen comes along, it immediately attaches to the antibody in the cell membrane; this leads to the activation process. In the case of the T lymphocytes, there are surface receptor

proteins (or T-cell markers) on the surface of the T-cell membrane which are also highly specific for one specified activating antigen. There are as many as 1,00,000 receptor sites on a single T cell (Hall, 2016).

Both the Humoral and Cell-mediated Response follow certain general steps that can be broken down into the following (Payne, 2007).

(a) Antigen is trapped

(b) The antigen is recognized by T and B Cells.

(c) Antigen is eliminated

(d) Memory is established due to the presence of long-lived T and B cells

Humoral Immunity

When a foreign antigen enters the body, the macrophages in the lymphoid tissue phagocytize the antigen and then present it to the B cells. The antigen is also presented to the T cells thus becoming helper T cells which also contribute to the activation of the B cells.

Such activated B cells enlarge and form lymphoblasts. Some of these lymphoblasts further differentiate to form plasmablasts, which are the precursors of plasma cells. The plasmablasts then divide as a result of which about 500 cells are formed from each original plasmablast. The mature plasma cell then produces the antibodies at an extremely rapid rate — about 2000 molecules per second for each plasma cell. This is the primary response. These antibodies are secreted into the lymph and carried to the circulating blood. This process continues for several days or weeks until finally exhaustion and death of the plasma cells occur. The antibodies inactivate the invading agent by one of the many ways such as agglutination (by binding the antigens together into a clump), precipitation (by rendering the antigen insoluble and precipitates), neutralization (by covering the toxic sites of the foreign agent) or lysis (rupturing the agent by directly attacking the membranes) (Hall, 2016).

Some of the lymphoblasts form moderate numbers of new B lymphocytes similar to the original lymphocytes. They also circulate throughout the body and populate the lymphoid tissue. But these are immunologically dormant till they are exposed to or activated by the same antigen again. These B cells or B lymphocytes are called memory cells. As a result, on subsequent exposures to the same antigen, there are increased number of B lymphocytes circulating in the body which will eventually produce increased number of antibodies at a faster rate on subsequent exposure to the same antigen. This will be the secondary response (Hall, 2016). The same principle is being followed in vaccination or immunization wherein multiple doses of the antigen are administered with periods ranging from several weeks to several months between the two. Formation of plasma cells and memory cells are presented in the form of flow chart in Fig. 1.

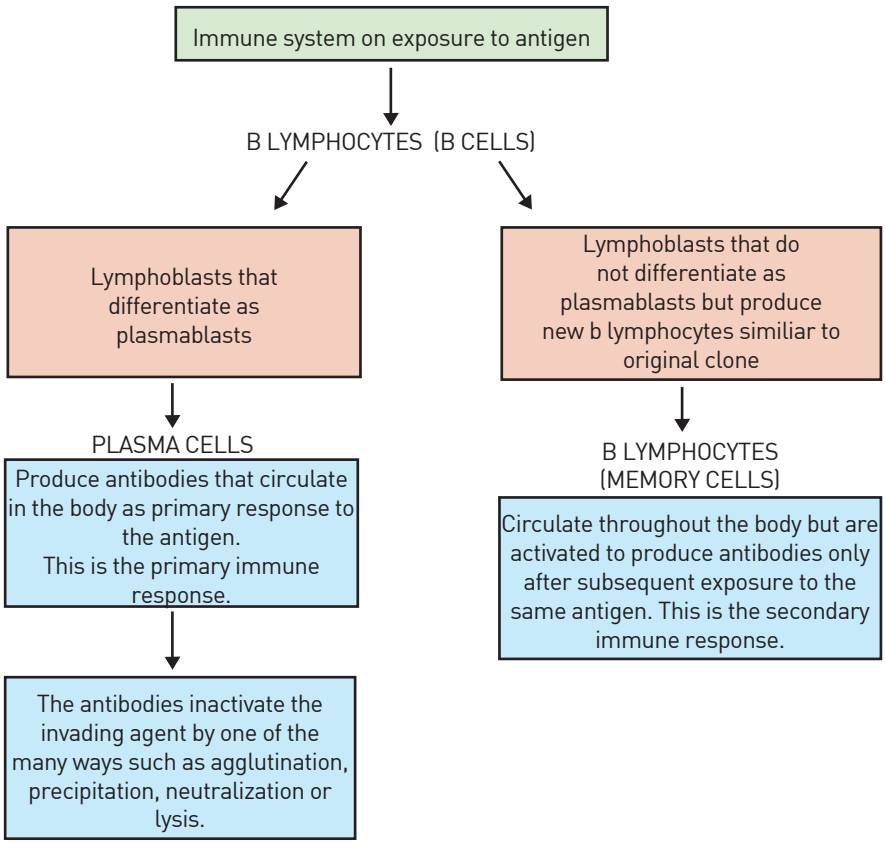

Fig. 1. Hummoral Immune Response

Cell-Mediated Immunity

Cell-mediated immunity involves T cells. On exposure to specific antigen, as presented by the antigen presenting cells (APCs), the specific T lymphocytes proliferate and release large numbers of activated, specifically reacting T cells as in the case of B cells. It may be mentioned that unlike B lymphocytes that recognise intact antigens, T lymphocytes respond to antigens only when they are bound to specific molecules called Major Histocompatibility Complex (MHC) proteins on the surface of APCs. There are three major types of APCs — macrophages, B lymphocytes and dendritic cells. The dendritic cells, the most potent of the APCs, are located throughout the body, and their only known function is to present antigens to T cells. The principal function of the MHC is to present antigen to T cells to discriminate between self (our cells and tissues) and non-self (the invaders or modified self)(Immunopedia.org). There are two types of MHC proteins: (1) MHC I proteins, which present antigens to cytotoxic T cells, and (2) MHC II proteins, which present antigens to T helper cells (Hall, 2016).

These activated T cells are released into the lymph from where they circulate throughout the body reaching the tissue spaces and then back into the lymph and blood again. This lasts for months or even years. As in the case of B memory cells, T-lymphocyte memory cells are also formed. Many of the newly formed lymphocytes are preserved in the lymphoid tissue to become additional T lymphocytes specific for an antigen. As in the case of B memory cells, subsequent exposure to the same antigen, activated T cells are released very rapidly and much more robustly than during the first exposure.

Cell-mediated immunity majorly involves helper T cells (or T-helper cells) and cytotoxic T cells. The role of the helper T cell is to activate cytotoxic T cell (Alberts et al., 2002). They also activate the macrophages to cause far more efficient phagocytosis by forming lymphokines. Cytotoxic T cells directly attack and kill the foreign agent (e.g., cell attacked by SARS-CoV-2). Helper T cell also stimulate B cells. They do this by secreting hole-forming proteins called perforins that literally punch round holes in the membrane of the attacked cell. Because of this, cytotoxic T cells are also called killer cells (Hall, 2016) (Fig. 2).

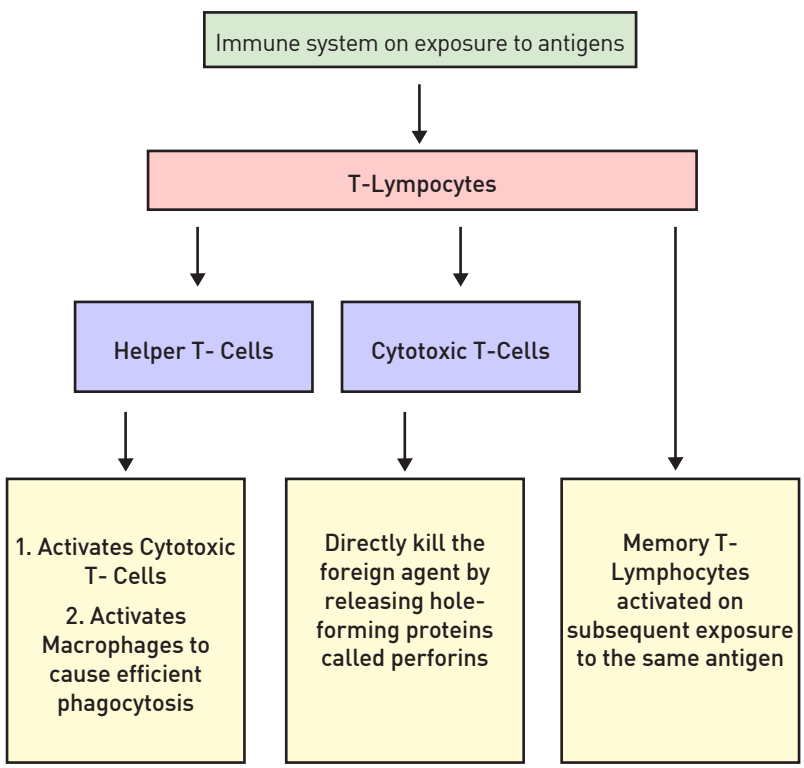

Fig. 2. Cell-mediated Immune R esponse

SARS-CoV-2 Infection and the Immune Response

In the case of SARS-CoV-2, infection begins with the entry of the virus through our nasal cavity, eyes or mouth. Following this, they come in contact with Angiotensin Converting Enzyme 2 (ACE2) receptors in the lining such as in the lining of respiratory tract and binds with them. The virus enters the cells through this receptor, hijacks the cell's machinery making large number of copies of itself and invades new cells. The events that occur during SARS-CoV-2 infection and the immune response against the infection is presented diagrammatically in Fig. 3.

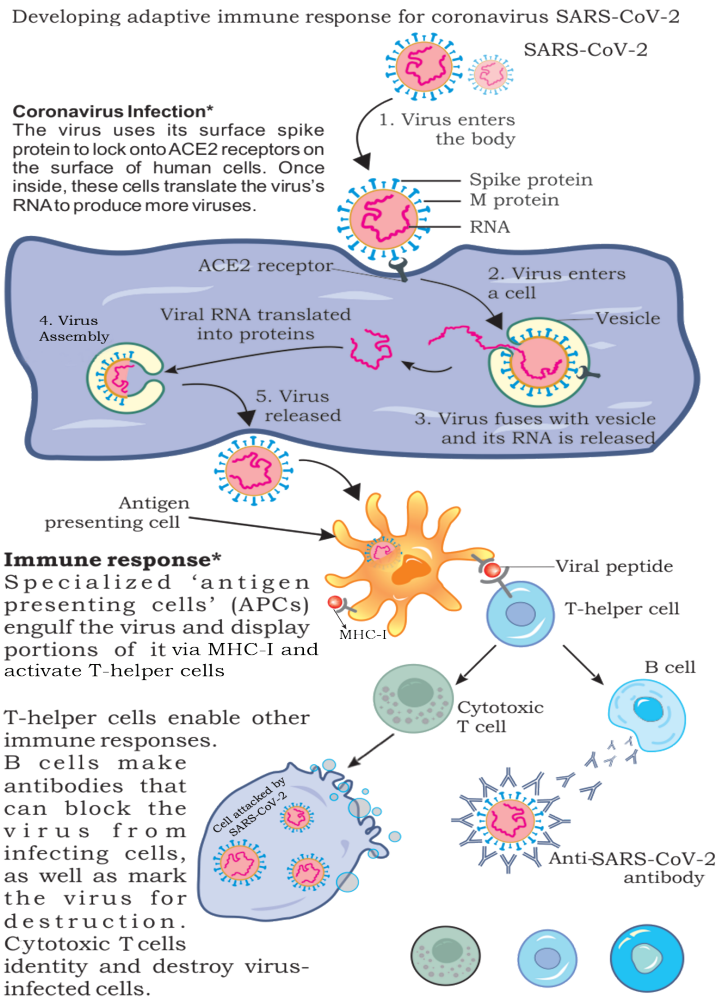

Fig. 3. Cell-Mediated Immune Response against SARS-CoV-2

The virus is transmitted through one of the following modes as described in WHO scientific brief:

- Contact and droplet transmission (including fomite transmission)
- Airborne Transmission
- Fecal Transmission

The incubation period for COVID-19 i.e., the time from exposure to SARS-CoV-2 to the time when symptoms begin to show is, on average, 5–6 days and can range from 1–14 days. Therefore people who have been exposed to the virus are advised to remain at home and stay away from others, for 14 days, in order to prevent the spread of the virus, especially where testing is not easily available.

The most common symptoms of COVID-19 are: Fever, dry cough and fatigue. Other symptoms that are less common and may affect some patients include: Loss of taste or smell, nasal congestion, conjunctivitis (also known as red eyes), sore throat, headache, muscle or joint pain, different types of skin rash, nausea or vomiting, diarrhea, chills or dizziness, irritability, confusion, reduced consciousness (sometimes associated with seizures), anxiety, depression, sleep disorders. More severe and rare neurological complications such as strokes, brain inflammation, delirium and nerve damage are also reported. Symptoms of severe COVID-19 disease include: Shortness of breath, loss of appetite, confusion, persistent pain or pressure in the chest, high temperature (above 38°C).

Among those who develop symptoms, most (about 80%) recover from the disease without needing hospital treatment. About 15 per cent become seriously ill and require oxygen, and 5 per cent become critically ill and need intensive care. Complications leading to death may include respiratory failure, acute respiratory distress syndrome (ARDS), sepsis and septic shock, thromboembolism and/or multiorgan failure, including injury of the heart, liver or kidneys. In rare situations, children can develop a severe inflammatory syndrome a few weeks after infection (WHO, 2021).

Passive Immunity

All the acquired immunity we have discussed so far has been active immunity. That is, the person's own body develops either antibodies or activated T cells in response to invasion of the body by a foreign antigen. However, temporary and brief immunity can be accomplished in a person without prior exposure to an antigen. This is done by administering antibodies, activated T cells, or both, obtained from the blood of someone else or from some other animal that has been actively immunized against the antigen. In such cases, antibodies last in the body of the recipient for 2 to 3 weeks, and during that time, the person can be protected against the invading agent. However, the efficacy of such treatment depends upon the invading agent. On the other hand, activated T cells last for a few weeks if transfused from another person but only for a few hours to a few days if transfused from an animal. Such transfusion of antibodies or T lymphocytes to confer immunity is called passive immunity.

Conclusion

So if the human body has evolved such a powerful system over millions of years, where do vaccines and other treatments fit into

all this? As mentioned earlier, this adaptive immunity can take many days or even weeks to establish. There is time kinetics at play. Will our immune system subdue the pathogen, or will the pathogen unleash its effect and damage our cells and make us sick to the extent that the person might die before the immune system subdues the pathogen? In the context of the SARS-CoV-2, from the day we are infected, it can take almost two weeks for the immune response to ramp up, enough time for this virus to swarm through our body wreaking havoc. In some people, this damage becomes overwhelming, and they die (WHO, 2020). This is where treatment helps and vaccination has been found to be effective to deal with several epidemics and pandemics including COVID-19. The details about vaccines and vaccination will be discussed in the second part of this article.

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AN INTRODUCTION TO IMMUNE SYSTEM WITH SPECIAL FOCUS ON VACCINES FOR SARS-COV-2: PART II

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This is the second part of the two-part article. It will deal with vaccines, vaccine design and types of vaccines, trials during the development of a vaccine, and the process of approval by concerned authority for public use. It will also discuss on the various strategies used in vaccines against SARS-CoV-2 that cause COVID-19 by taking some examples of the recently approved vaccines

Keywords: Immune system, vaccines, vaccine trials, vaccine design.

Introduction

In part I of the two-part article, we have discussed about pathogens and how the immune system responds to the pathogens. We have also discussed about the types of immune system — innate immune system and adaptive immune system. Under the latter, we discussed about humoral immunity and cell-mediated immunity. The sequence of events that follow SARS-CoV-2 infection have also been dealt in brief. This article, which is the second part of the two-part article, will focus on vaccines and vaccine design, how vaccines are developed and how they provide immunity to specific diseases especially in the context of the coronavirus, SARS-CoV-2. The article will also discuss on the various steps involved in the process of vaccine trials, approval and dissemination. Readers will also get familiarized with the few approved vaccines for COVID-19.

Vaccines

Innovative therapeutic interventions have been in use for centuries and are critical to prevent and treat human and animal diseases. It could be injecting antibodies, those molecules that would subdue the virus, either made synthetically in the lab or from the blood of people who have recovered (Plasma Therapy). Sometimes drugs could help by entering our cells and blocking the virus from copying itself and making the virus less deadly. But the best way to beat an infection and stop a pandemic is using a vaccine. And it does so by taking advantage of something that our bodies have evolved over millions of years — Memory. As discussed in Part I, adaptive immune response produces memory B and T cells which will mobilize rapid and robust response upon re-exposure of the same antigen in case of actual infection. While drugs are administered to treat a medical

problem, vaccines are administered to prevent the appearance of a medical problem. Some exceptions can be found in both classes, such as cancer vaccines (vaccines that are administered after detection of the problem) and proton pump inhibitors (drugs that are often administered to prevent gastric problems in co-therapy with other drugs). Notwithstanding, vaccines and drugs are similarly regulated both in research and development, manufacturing, clinical trials, government approvals, and regulation. In the big picture, a vaccine is a special type of drug. There are also few other differences. For example, for vaccines, dose, time, route and frequency are generally established. In contrast, since drugs are used for patients with different conditions, dose, time and frequency of drug administration are often very difficult to determine (He et al., 2012). Also, unlike most drugs, whose benefit is restricted to the individual who takes the drug, vaccines have the potential for far-reaching effects that encompass health service utilization, general health and well-being, and ultimately economic productivity. The impact of vaccines is measured by evaluating effects directly on the vaccinated individuals, indirectly on the unvaccinated community, the epidemiology of the pathogen (such as changing circulating serotypes) and additional benefits arising from improved health. Aside from the protection of the individual, the broader success of vaccination is dependent on achieving a level of coverage sufficient to interrupt transmission of the pathogen (Doherty et al., 2016). This suggests that vaccination of a huge chunk of a population is necessary to interrupt transmission of the pathogen through herd (population) immunity or herd protection (i.e., the indirect protection provided to unvaccinated individuals in a population resulting from most of the population having got vaccinated).

Early attempts in the development of vaccines were based on the observation that people surviving a disease, for example, a person who has recovered from Small Pox, was protected against further occurrence of that particular disease. From the vantage point of today's understanding, we know that it is the immune response and its memory (be it B or T cells). The goal of the vaccination is to fake an infection that exposes the body to an antigen that will not cause disease but will provoke an immune response that can block or kill the virus. To fake this infection, there are various ways by which viral antigens or viral toxins or viral proteins can be delivered as vaccines which are discussed in the next section.

Vaccine design, strategies, advantages and disadvantages

Vaccine design has made significant strides in the last century, evolving from serendipity to a more rational approach thanks to our understanding of immunological mechanisms, our insight into the molecular details of virus replication and pathogenesis (Delany et al., 2014).

Vaccines are broadly divided into two — live, attenuated (weakened in a laboratory) vaccines and non-live/ killed/ inactivated (which have lost its pathogenicity but not its antigenicity) vaccines. Two essential things that have to be taken into account while vaccine development is first safety, considering that vaccine is given mostly to healthy individuals, and secondly efficiency or efficacy, to overcome an infection intended for (Payne, 2017). A key consideration

in developing a vaccine is whether or not the vaccine contains a source of live infectious material. Vaccines containing live infectious agents carry a virus (or bacteria) that replicates just enough to stimulate a protective response in the vaccine recipient but not enough to cause harm. However, since they contain live infectious agents, they may revert to its virulent form and cause the disease, but this happens very rarely. Vaccines that are not live and that do not contain infectious agents, called Non-Live Vaccines, do not contain sources of infectious material and therefore do not cause disease. Hence they generally have a good safety profile, even in immunocompromised individuals. However, a drawback of these vaccines is that immunogenicity and duration of protection tend to be less compared to live vaccines, and they may require several doses to improve immunogenicity. Many times adjuvants are added to the vaccine. Adjuvants are substances that enhance and modulate the immunogenicity of the antigen. Adjuvants are usually not needed for live attenuated vaccines because the viruses in

Table 1
Overview of the advantages and disadvantages of the major vaccine strategies and examples of licensed vaccines

<table>
<tr><td rowspan="3"></td><td>Vaccines that contain live or infectious Particles (Live Attenuated Vaccines)</td><td colspan="5">Vaccines that do not contain Live or infectious Particles: Non-Live Vaccines (Inactivated Vaccines)</td></tr>
<tr><td rowspan="2">Attenuated or Weakened Live Pathogen Vaccine</td><td rowspan="2">Inactivated or Killed Pathogen Vaccine</td><td colspan="4">Subunit Vaccines</td><td rowspan="2">Viral Vector Vaccine</td></tr>
<tr><td>Protein Vaccine</td><td>Toxoid Vaccine</td><td>Virus-like Particles Vaccine</td><td>Nucleic Acid Vaccine</td></tr>
</table>

Strategy employed	It is obtained by repeated passing of the virus through a series of in-vitro cell cultures. With each passage, the selected virus progressively loses its ability to infect and replicate in the human host but causes a minimal infection.	It is produced by inactivating preparations of whole pathogens by heat, radiation, or chemicals such as formalin or formaldehyde. Inactivation destroys the pathogens' ability to replicate and cause the disease but maintains its immunogenicity	Here antigenic proteins are purified(Extracted) from preparations of the whole pathogen or produced by recombinant genetic engineering.	Some bacteria such as Clostridium tetani, Clostridium difficile cause disease by releasing pathogenic toxins. These vaccines for such diseases are produced by detoxifying the toxin using heat, chemicals but retain the antigenic potency (e.g., formaldehyde), or both.	Based on the observation that the expression of certain viral proteins leads to the spontaneous assembly of particles structurally similar to the original viruses	Nucleic acid vaccines encode for pathogen antigen. These vaccines work by inserting DNA or RNA into vectors(Delivery vehicles) which carry and release the same into host cells. The administered mRNA or DNA uses the host cell transcription and translation machinery to produce viral antigen.	It is a recombinant vaccine which uses a vector to carry the recombinant genetic material but it cannot replicate. For e.g., the chimpanzee adenovirus encodes the SARS-CoV-2 Spike protein (i.e., the Spike protein gene of SARS-CoV-2 is added in the DNA of the adenovirus). Thus the adenovirus can produce the Spike protein but cannot replicate.

Advantages	Usually, produce robust Cell-mediated and Humoral immune responses with just one dose. Long-lasting immune response (sometimes lifelong).	Safe as the pathogen is dead. Transport and storage.	Safety during production. It can be safely administered to immunocompromised individuals. No infectious agent is required while handling.	Non-infectious. They are used as carrier proteins due to good immunogenicity	Combine the efficacy of attenuated vaccines and safety of subunit vaccines. Scalability of production. Their size is ideal for the uptake of the cell.	Scalability. Fast design and development. Extremely safe. No infectious agent handling is required. Can induce humoral and cellular responses.	Admistration of this vaccine will not cause COVID-19. There is drastic reduction in the rate of infection or severe infection after two dose of this vaccine.
Disadvantages	Safety issues in immunocompromised individuals. Development of the vaccine takes time. Though very rare, but potential to revert back to a form able to cause the disease (e.g. Oral polio vaccine).	Large quantities of the pathogen need to be processed. The inactivation process can affect antigen immunogenicity. Antibody titers reduce over time. Need several booster doses.	Low immunogenicity. Need several booster doses and adjuvant. Production is limited by antigen production scalability.	Vaccines target only the toxin and do not prevent infection by the pathogen. No herd protection. Priming and boosting necessary.	The assembly of particles is sometimes challenging.	DNA vaccines require a unique delivery platform. mRNA vaccines exhibit instability and require storage at -20°C	Storage and transportation is sometimes an issue as they require very low temperature. For example, Pfizer COVID-19 vaccine needs to be stored below minus 40°C

Licensed Vaccines that use this strategy	Mumps, Measles, rotavirus, Rubella, varicella, Oral Polio, Yellow Fever, Chickenpox, BCG	Whole-cell pertussis, rabies, Polio, Hep A, Covaxin and CoronaVac for COVID-19	Hep B, Hep C, Influenza, Acellular pertusis, HPV	Tetanus, diphtheria, acellular pertussis	HPV, Hep B	Moderna and Pfizer/ BioNTech COVID-19 vaccine	Oxford–Astra-Zeneca COVID-19 vaccine (Eg. Covishield, Vaxzevria), Hepatitis B

the vaccine actively replicate and self enhance the immune response. However, they are frequently used for non-live vaccines because they contain fewer antigens and lack some of the intrinsic components present in the whole pathogens that trigger the innate immune response so that an effective downstream adaptive response is less likely to be achieved (Vetter et al., 2018). For almost a century, aluminum salts (also known as Alum) were the only adjuvant approved worldwide, and they are still in use. Table 1 discusses the strategy, advantages, and disadvantages of various vaccines (CDC, 2015; Kyriakidis et al., 2021; Vetter et al., 2018).

How trials are done, volunteers chosen, phases of trials, and time it takes for mass use

Each vaccine at the time of development must first undergo screenings and evaluations to determine which antigen should be used to invoke an immune response. This preclinical phase involves an experimental vaccine that is first tested in animals to evaluate its safety and potential to prevent disease.

If the vaccine triggers an immune response, it is then tested in humans in three phases.

Phase 1

This phase involves giving the vaccine to a small number of volunteers to assess its safety, to confirm that it generates an immune response, and determine the lower and upper limit of dosage. Generally, in this phase, vaccines are tested in young, healthy adult volunteers.

Phase 2

The vaccine is then given to several hundred volunteers to further assess its safety and ability to generate an immune response. Participants in this phase have the same characteristics (such as age, sex) as the people for whom the vaccine is intended. This phase involves multiple trials to evaluate various age groups and different formulations of the vaccine. A group that did not get the vaccine is usually included in the phase as a comparator group (Placebo group; many a time innocuous saline water is injected) to determine whether the immunity achieved in the vaccinated group is attributed to the vaccine or has happened by chance.

Phase 3

In this phase, the vaccine is given to thousands of volunteers – and compared to those who receive a comparator product – to

determine if the vaccine is effective against the disease it is designed to protect against and study its safety in a much larger group of people. Most of the time, phase three trials are conducted across cities, within a country and foreign to assure the vaccine performance findings apply to many different populations.

During phase two and phase three trials, the volunteers and the scientists conducting the study are shielded from knowing which volunteers had received the vaccine being tested or the comparator (placebo) product. This is called "blinding," which is necessary to assure that neither the volunteers nor the scientists are prejudiced in their assessment of safety or effectiveness by knowing who got which product (WHO, 2020).

Role of Government agencies and other public organizations

When the results of all these clinical trials are available, a series of steps are taken, which includes reviews of efficacy and safety for regulatory and public health policy approvals. Officials then closely review the report and decide whether to authorize the vaccine for use. A vaccine must show clear evidence that it is safe and effective across a broad population before being approved and introduced into a national immunisation program. The bar for vaccine safety and efficacy is exceptionally high, considering that vaccines are given to people who are healthy and specifically free from the illness. Further monitoring takes place even after the vaccine is introduced, enabling scientists to keep track of vaccine impact and safety even as they are used in many people over a long period. The data obtained is used to adjust the policies for vaccine use and optimize their impact. Once a vaccine is in use, it must be continuously monitored to ensure it continues to be safe (WHO, 2020). Governments are also involved in something called Vaccine diplomacy. The COVID-19 vaccine — one of the worlds' most in-demand commodities today — has become a new currency for international diplomacy. Countries with the means and the know-how are using vaccines to find favor or thaw frosty relations. As such, India, the unmatched vaccine manufacturing powerhouse, is doling millions of doses to friendly neighbors and needy countries.

SARS-CoV-2 Vaccine strategies: A review of few approved vaccines

COVID-19 is caused by new positive-strand RNA coronavirus (SARS-CoV-2), which belongs to the Coronaviridae family, along with the severe acute respiratory syndrome (SARS) and the middle east respiratory syndrome (MERS) coronavirus. The majority of vaccines for COVID-19 employ administration of viral antigens or viral gene sequences aiming to induce neutralising antibodies against spike protein (Kyriakidis et al., 20210. Herein, we discuss the different strategies that were used for vaccine development against SARS-CoV-2.

CoronaVac, developed by Sinovac Biotech in China, is a purified inactivated virus alum-adjuvant vaccine. It is formalin-inactivated (Ref. 1). The vaccine is administered in two doses, 14–28 days apart. The phase-III trials included 8870 participants from Brazil, Indonesia, and Turkey (Kyriakidis et al., 2021). Reports have shown that it was 50.4 per cent effective at preventing severe and mild COVID-19 in late-stage trials (Ref. 10).

Vaccines based on inactivated pathogens are produced by inactivating preparations of whole pathogens by heat, radiation or chemicals such as formalin or formaldehyde. Inactivation destroys the pathogens' ability to replicate and cause the disease but maintains its immunogenicity so that the immune system can still recognize the targeted pathogen. Inactivated vaccines present some technical challenges as a disadvantage. The inactivation process can sometimes damage the antigens leading to suboptimal immunogenicity. Therefore these need several boost doses to produce strong immune responses. Besides these vaccines need the addition of adjuvants. While response induced is less than Live attenuated vaccines, these vaccines are easily handled, generally less expensive, and much safer (Forni et al., 2021).

Covaxin, developed by Bharat Biotech and the Indian Council of Medical Research, is another inactivated vaccine rolled out for use against COVID-19. The vaccine was developed by inactivating an Indian strain of the novel coronavirus isolated by the Indian National Institute of Virology. A Phase 3 trial of 26,000 participants is still underway as this article was being written. However, it has been approved, based on the positive results shown in phase I/II by the Drugs Controller General of India (DCGI), which is responsible for approval of licenses of specified categories of drugs such as blood and blood products, IV fluids, vaccines, and sera in India. Covaxin is a two-dose 6µg vaccine administered 28 days apart (Ref. 10).

Moderna and Pfizer/BioNTech have developed vaccines based on mRNA techniques. This is the first mRNA vaccine licensed to be used in humans. How mRNA and DNA vaccines induce immunity is provided in figure 1. Researchers started with the genetic sequence of the COVID-19 and worked backward to find the mRNA that expresses the spike protein. This mRNA of the SARS-CoV-2 is incorporated in the lipid nanoparticle. Upon vaccination, lipid nanoparticle fuses with the host cell membrane. Here nanoparticle releases mRNA. Translation of mRNA to proteins takes place without tampering with the nucleus of the host cell (i.e., in the cells of human body). These proteins are then presented on the cell by MHCs. Here's when adaptive immune response kicks in. Helper T cell recognizes and releases cytokines that signal B cells to proliferate and produce antibodies, and the memory of the same is stored if an actual infection does occur [Kyriakidis et al., 2021].

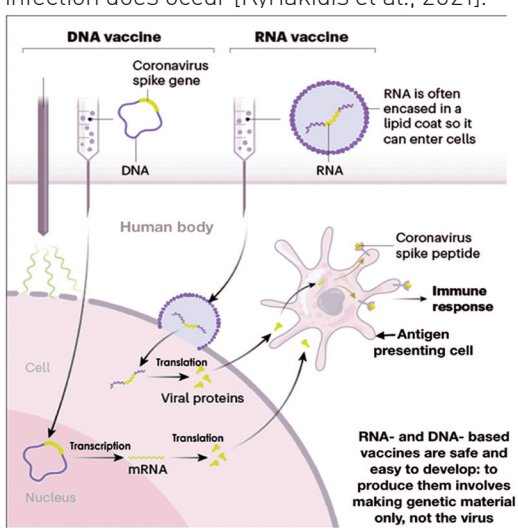

Fig. 1. Inducing immunity by Nucleic and Vaccines: Spearhead Candidates for COVID-19. [Ewen Calaway, 2021]

While Moderna had 30000 participants in phase III and reported 94.1 per cent efficiency, Pfizer had 44000 participants and achieved

95 per cent efficiency overall and 94 per cent in the age group of 65 years and above (Ref. 1).

Covishield, which is rolled out by Serum Institute of India, the largest Vaccine manufacturer in the world capable of producing 5000 doses per minute, is based on the vaccine developed by Oxford University and AstraZeneca. In this case, a DNA molecule derived from the S-protein of the SARS-CoV-2 virus is inserted into Chimpanzee Adenovirus. When this virus (not pathogenic to the human body) is injected, it fuses with the host cell and releases the DNA inside. DNA gets converted to mRNA by transcription. mRNA gets converted to viral proteins through translation which is later presented for adaptive immune response by MHCs (Kyriakidis et al., 2021). Covishield had 30000 participants with an efficiency of 62.14 per cent overall and about 90 per cent in the age group of 18–55 years. Covishield is administered in two doses between 12–16 weeks apart. Janssen Vaccines, a company owned by Johnson & Johnson, has developed JNJ-78436735 (formerly known as Ad26.COV2.S), a single-dose COVID-19 vaccine using the same DNA technique. They had whopping 90000 participants in phase III trials and were 66 per cent effective overall (Ref. 10). These two nucleic acid techniques have saved us months of time and tons of money. Other traditional vaccine development strategies, such as attenuated virus vaccines, although historically leading to very successful vaccines against viral diseases, require long cell culturing processes to achieve attenuated strains. In these two cases, the only ingredient required is the genetic sequence of the SARS-CoV-2 virus [Kyriakidis et al., 2021].

Conclusion

Traditionally, it takes 10 to 15 years to develop a vaccine, although there are exceptions. It took just four years to develop and secure approval for a mumps vaccine that was first licensed in 1948 and 5 years in the case of the Ebola vaccine, which was approved in December 2019. But, what has happened with COVID-19 vaccine development is astonishing with the research work being carried out at a breathtaking pace and rolling of vaccines for use in less than a year. The latest technologies, innovative platforms, and state-of-art labs and manufacturing units, along with overlapping and truncating few regulatory procedures without compromising safety, have helped us blaze through so quickly. For a world to be free of the current pandemic, WHO advocates that at least 60 per cent of the human population be vaccinated. We are very much in this direction, having administered close to 180 million doses in such a short time. These vaccines are found to induce higher neutralizing antibody titers than natural infection with very mild side effects in the fractional population to absolutely no side effects in the vast majority (Kyriakidis et al., 2021). Having said that, only time will reveal long-term side effects, if any, and the scientific community's integrity and transparency. The road ahead is also becoming razor-sharp as the SARS-CoV-2 is mutating rapidly, showing different variants in different countries, for which the vaccine should be tweaked appropriately. Nevertheless, we are confident that the scientists who have ferried us so far will also develop solutions for mutating virus.

But are vaccines always an answer? Should we not develop a good and natural immune system by leading a healthy lifestyle? Because with the next new virus, the world will run around again in frenzied chaos. As they say, good police (vaccine) can catch a thief, but if we have a good policing system (sound natural immune system in this context) in place, we could have ensured that theft did not happen in the first place. It is also about time to learn to not play with nature to prevent other zoonotic diseases which could be as infectious and deadly as SARS-CoV-2, if not more.

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SCIENCE NEWS

Could we recycle plastic bags into fabrics of the future?

Engineers have developed self-cooling fabrics from polyethylene, a material commonly used in plastic bags
Date: March 15, 2021
Source: Massachusetts Institute of Technology
Summary: Engineers have developed self-cooling fabrics from polyethylene, commonly used in plastic bags. They estimate that the new fabric may be more sustainable than cotton and other common textiles.

Engineers have developed self-cooling fabrics from polyethylene, a material commonly used in plastic bags. In considering materials that could become the fabrics of the future, scientists have largely dismissed one widely available option: polyethylene.

The stuff of plastic wrap and grocery bags, polyethylene is thin and lightweight, and could keep you cooler than most textiles because it lets heat through rather than trapping it in. But polyethylene would also lock in water and sweat, as it's unable to draw away and evaporate moisture. This antiwicking property has been a major deterrent to polyethylene's adoption as a wearable textile.

Now, MIT engineers have spun polyethylene into fibers and yarns designed to wick away moisture. They wove the yarns into silky, lightweight fabrics that absorb and evaporate water more quickly than common textiles such as cotton, nylon and polyester.

They have also calculated the ecological footprint that polyethylene would have if it were produced and used as a textile. Counter to most assumptions, they estimate that polyethylene fabrics may have a smaller environmental impact over their life cycle than cotton and nylon textiles.

The researchers hope that fabrics made from polyethylene could provide an incentive to recycle plastic bags and other polyethylene products into wearable textiles, adding to the material's sustainability.

"Once someone throws a plastic bag in the ocean, that's a problem. But those bags could easily be recycled, and if you can make polyethylene into a sneaker or a hoodie, it would make economic sense to pick up

these bags and recycle them," says Svetlana Boriskina, a research scientist in MIT's Department of Mechanical Engineering.

Boriskina and her colleagues have published their findings today in Nature Sustainability.

New insight into how cancer spread

Date: March 11, 2021
Source: University of Colorado Anschutz Medical Campus
Summary: Breast cancer is harmful enough on its own, but when cancer cells start to metastasize — or spread into the body from their original location — the disease becomes even more fatal and difficult to treat.

Breast cancer is harmful enough on its own, but when cancer cells start to metastasize — or spread into the body from their original location — the disease becomes even more fatal and difficult to treat.

Thanks to new research published in Oncogene from the lab of University of Colorado Cancer Center associate director of basic research Heide Ford, PhD, in collaboration with Michael Lewis, PhD, from Baylor College of Medicine, doctors may soon have a better understanding of one mechanism by which metastasis happens, and of potential ways to slow it down.

"Metastasis is a huge problem nobody's tackled very well," says Ford, who holds the Grohne Endowed Chair in Cancer Research at the University of Colorado School of Medicine. "People don't know how to inhibit the process of metastasis, nor how to inhibit the growth of metastatic cells at secondary sites. And that's what kills most cancer patients. A lot of common drugs, whether they're targeted drugs or chemotherapies that are less targeted, do pretty well at inhibiting the primary tumor, but by the time cells metastasize, they've changed enough that they don't get inhibited by those drugs."

The transformation Ford and her team are studying happens when cells called epithelial cells, which are more adherent to one another and less likely to spread to other parts of the body, start to take on the characteristics of mesenchymal cells, which are more migratory and more likely to invade other parts of the body. This transformation is referred to as the epithelial-to-mesenchymal transition.

"When the epithelial cancer cells take on these characteristics of mesenchymal cells, they become less attached to their neighbor and they become more able to degrade membranes, so they can get into the bloodstream more easily," Ford says.

In 2017, Ford published a paper showing that the metastasis process is helped along when cells that have undergone the epithelial-to-mesenchymal transition start "talking" to cells that haven't, making those cells more likely to gain metastatic properties.

In a new paper published in December, Ford and her researchers, in a collaborative study done with Lewis and colleagues at Baylor College of Medicine, posit that the crosstalk is facilitated by a naturally occurring protein called VEGF-C.

"VEGF-C is secreted by the cells. It binds to receptors on these neighboring cells and then activates a pathway called the hedgehog signaling pathway, though it bypasses the traditional way of activating this pathway," Ford says. "That turns on a signaling mechanism that ultimately results

in activation of a protein called GLI that makes these cells more invasive and more migratory."

In their new paper, Ford, Lewis and their researchers show that if you can inhibit production of VEGF-C, you can significantly slow metastasis.

"If you take out the receptor that receives the signal from the cells that have not undergone a transition, or if you take VEGF-C out of the mix, you can't stimulate metastasis to the same degree," she says. "If you remove that ability for these different cell types to crosstalk, now these cells that never underwent a transition can't move as well anymore. They can't metastasize as efficiently."

The researchers are now in the early stages of animal trials to find out the best way to target that signaling pathway in order to better inhibit metastasis. They want to find out if they can stop metastasis from happening at all, and if they can slow its progression in patients in whom the metastatic process has already begun — and to see if they can inhibit tumor growth at the secondary site.

"For many years, people said there was no point in finding inhibitors to metastasis because by the time someone comes into the clinic, the horse is out of the barn, so to speak. The cells have already gotten out of the primary tumor and you can't do anything about it," Ford says. "But that's not necessarily true. Now, data show that if you have cells that have metastasized to a second site — say you have breast cancer and the cells went into the lungs — those cells that are in the lungs could in fact start metastasizing to other sites. You want to stop that process no matter where you are in this progression."

Electricity could help speed wound healing, new study shows

Electrical impulses may help vessels more quickly get healing agents to injuries
Date: March 11, 2021
Source: Ohio State University
Summary: Electric stimulation may be able to help blood vessels carry white blood cells and oxygen to wounds, speeding healing, a new study suggests.

The study, published in the Royal Society of Chemistry journal Lab on a Chip, found that steady electrical stimulation generates increased permeability across blood vessels, providing new insight into the ways new blood vessels might grow.

The electrical stimulation provided a constant voltage with an accompanying electric current in the presence of fluid flow. The findings indicate that stimulation increases permeability of the blood vessel — an important characteristic that can help wound-healing substances in the blood reach injuries more efficiently.

"There was this speculation that blood vessels could grow better if you stimulated them electrically," said Shaurya Prakash, senior author of the study and associate professor of mechanical and aerospace engineering at The Ohio State University. "And we found that the response of the cells in our blood vessel models shows significant promise towards changing the permeability of the vessels that can have positive outcomes for our ongoing work in wound healing."

Blood vessels are crucial for wound healing: They thread throughout your body, carrying nutrients, cells and chemicals that can help control inflammation caused by an injury. Oxygen and white blood cells — which protect the body from foreign invaders — are two key components delivered by blood vessels.

But when there is an injury — for example, a cut on your finger — the architecture of the blood vessels at the wound site are disrupted. That also interrupts the vessels' ability to help the wound heal. Blood vessels regrow on their own, almost like the branches of trees, without external sources of electricity, as part of the healing process.

"And as the blood vessels begin to grow, they replenish the skin and cells and establish a healing barrier again," Prakash said. "But our question was: How do you make this process better and faster, and is there any benefit to doing that?"

What they found, in laboratory tests performed using human cells, is that stimulating blood vessels with electricity showed a marked increase in blood vessel permeability, which is a physical marker suggestive of possible new vessel growth.

"These initial findings are exciting, and the next phase of the work will require us to study if and how we can actually grow new vessels," Prakash said.

Jon Song, co-author of the paper and associate professor of mechanical and aerospace engineering at Ohio State, said the results imply that one of the primary ways blood vessels work to heal injuries is by allowing molecules and cells to move across the vessels' walls.

"And now we have better understanding for how electric stimulation can change the permeability across the vessel walls," Song said. "Let's say you have a cutaneous wound, like a paper cut, and your blood vessels are severed and that's why you have blood leaking out. What you need is a bunch of bloodborne cells to come to that place and exit out the blood vessel to initiate the wound repair."

The study suggested that changes in blood vessel permeability could get those bloodborne cells to a wound site more quickly, though it did not explain the reasons why that happened. The study seemed to indicate that electricity affected the proteins that hold blood vessel cells together, but those results were not conclusive.

The study is an extension of work by a broader team, led by Prakash, that previously showed electric bandages could help stimulate healing in wounded dogs. That work indicated that electrical stimulation might also help manage infections at wound sites — a phenomenon the researchers also hope to research further.

The secret of catalysts that increase fuel cell efficiency

Date: March 10, 2021
Source: Pohang University of Science & Technology (POSTECH)
Summary: A research team reveals the phase transition and metal ex-solution phenomena to increase the catalytic activity.

Fuel cells, which are attracting attention as an eco-friendly energy source, obtain electricity and heat simultaneously through the reverse reaction of water electrolysis. Therefore, the

catalyst that enhances the reaction efficiency is directly connected to the performance of the fuel cell. To this, a POSTECH-UNIST joint research team has taken a step closer to developing high-performance catalysts by uncovering the ex-solution and phase transition phenomena at the atomic level for the first time.

A joint research team of Professor Jeong Woo Han and Ph.D. candidate Kyeounghak Kim of POSTECH's Department of Chemical Engineering, and Professor Guntae Kim of UNIST have uncovered the mechanism by which PBM0 — a catalyst used in fuel cells — is transformed from perovskite structure to layered structure with nanoparticles ex-solution1 to the surface, confirming its potential as an electrode and a chemical catalyst. These research findings were recently published as an outside back cover paper of the Energy & Environmental Science, an international journal in the field of energy.

Catalysts are substances that enhance chemical reactions. PBM0 (Pr0.5Ba0.5Mn03-δ), one of the catalysts for fuel cells, is known as a material that stably operates even when directly used as a hydrocarbon, not hydrogen. In particular, it exhibits high ionic conductivity as it changes to a layered structure under a reduction environment that loses oxygen. At the same time, the ex-solution phenomenon occurs in which the elements inside the metal oxide segregate to the surface.

This phenomenon occurs voluntarily under a reduction environment without any particular process. As the elements inside the material rise to the surface, the stability and performance of the fuel cell improve immensely. However, it was difficult to design the materials because the process through which these high-performance catalysts were formed was unknown.

Focusing on these features, the research team confirmed that the process goes through a progression of phase transition, particle ex-solution, and catalyst formation. This was proved using the first-principles calculation based on quantum mechanics and the in-situ XRD2 experiment that allows the observation of real-time crystal structural changes in materials. The researchers also confirmed that the oxidation catalyst developed this way displays up to four times better performance than the conventional catalysts, verifying that this study is applicable to various chemical catalysts.

"We were able to accurately understand the materials in atomic units that were difficult to confirm in previous experiments, and successfully demonstrated it thus overcoming the limitations of existing research by accurately understanding materials in atomic units, which were difficult to confirm in existing experiments, and successfully demonstrating them," explained Professor Jeong Woo Han who led the study. "Since these support materials and nanocatalysts can be used for exhaust gas reduction, sensors, fuel cells, chemical catalysts, etc., active research in numerous fields is anticipated in the future."

This research was conducted with the support from the Samsung Research Funding & Incubation Center and the Korea Institute of Energy Technology Evaluation and Planning.

Cactus pear as drought-tolerant crop for sustainable fuel and food

Cactus crops remove carbon from the atmosphere, provide biofuel, food and livestock feed
Date: March 5, 2021
Source: University of Nevada, Reno
Summary: Could cactus pear become a major crop like soybeans and corn in the near future, and help provide a biofuel source, as well as a sustainable food and forage crop? Researchers believe the plant, with its high heat tolerance and low water use, may be able to provide fuel and food in places that previously haven't been able to grow sustainable crops.

Could cactus pear become a major crop like soybeans and corn in the near future, and help provide a biofuel source, as well as a sustainable food and forage crop? According to a recently published study, researchers from the University of Nevada, Reno believe the plant, with its high heat tolerance and low water use, may be able to provide fuel and food in places that previously haven't been able to grow much in the way of sustainable crops.

Global climate change models predict that long-term drought events will increase in duration and intensity, resulting in both higher temperatures and lower levels of available water. Many crops, such as rice, corn and soybeans, have an upper temperature limit, and other traditional crops, such as alfalfa, require more water than what might be available in the future.

"Dry areas are going to get dryer because of climate change," Biochemistry & Molecular Biology Professor John Cushman, with the University's College of Agriculture, Biotechnology & Natural Resources, said. "Ultimately, we're going to see more and more of these drought issues affecting crops such as corn and soybeans in the future."

Fueling renewable energy

As part of the College's Experiment Station unit, Cushman and his team recently published the results of a five-year study on the use of spineless cactus pear as a high-temperature, low-water commercial crop. The study, funded by the Experiment Station and the U.S. Department of Agriculture's National Institute of Food and Agriculture, was the first long-term field trial of Opuntia species in the U.S. as a scalable bioenergy feedstock to replace fossil fuel.

Results of the study, which took place at the Experiment Station's Southern Nevada Field Lab in Logandale, Nevada, showed that Opuntia ficus-indica had the highest fruit production while using up to 80 per cent less water than some traditional crops. Co-authors included Carol Bishop, with the College's Extension unit, postdoctoral research scholar Dhurba Neupane, and graduate students Nicholas Alexander Niechayev and Jesse Mayer.

"Maize and sugar cane are the major bioenergy crops right now, but use three to six times more water than cactus pear," Cushman said. "This study showed that cactus pear productivity is on par with these important bioenergy crops, but use a fraction of the water and have a higher heat tolerance, which makes them a much more climate-resilient crop."

Cactus pear works well as a bioenergy crop because it is a versatile perennial crop. When

it's not being harvested for biofuel, then it works as a land-based carbon sink, removing carbon dioxide from the atmosphere and storing it in a sustainable manner.

"Approximately 42 per cent of land area around the world is classified as semi-arid or arid," Cushman said. "There is enormous potential for planting cactus trees for carbon sequestration. We can start growing cactus pear crops in abandoned areas that are marginal and may not be suitable for other crops, thereby expanding the area being used for bioenergy production."

Fueling people and animals

The crop can also be used for human consumption and livestock feed. Cactus pear is already used in many semi-arid areas around the world for food and forage due to its low-water needs compared with more traditional crops. The fruit can be used for jams and jellies due to its high sugar content, and the pads are eaten both fresh and as a canned vegetable. Because the plant's pads are made of 90 per cent water, the crop works great for livestock feed as well.

"That's the benefit of this perennial crop," Cushman explained. "You've harvested the fruit and the pads for food, then you have this large amount of biomass sitting on the land that is sequestering carbon and can be used for biofuel production."

Cushman also hopes to use cactus pear genes to improve the water-use efficiency of other crops. One of the ways cactus pear retains water is by closing its pores during the heat of day to prevent evaporation and opening them at night to breathe. Cushman wants to take the cactus pear genes that allow it to do this, and add them to the genetic makeup of other plants to increase their drought tolerance.

Bishop, Extension educator for Northeast Clark County, and her team, which includes Moapa Valley High School students, continue to help maintain and harvest the more than 250 cactus pear plants still grown at the field lab in Logandale. In addition, during the study, the students gained valuable experience helping to spread awareness about the project, its goals and the plant's potential benefits and uses. They produced videos, papers, brochures and recipes; gave tours of the field lab; and held classes, including harvesting and cooking classes.

Fueling further research

In 2019, Cushman began a new research project with cactus pear at the U.S. Department of Agriculture — Agricultural Research Service' National Arid Land Plant Genetic Resources Unit in Parlier, California. In addition to continuing to take measurements of how much the cactus crop will produce, Cushman's team, in collaboration with Claire Heinitz, curator at the unit, is looking at which accessions, or unique samples of plant tissue or seeds with different genetic traits, provide the greatest production and optimize the crop's growing conditions.

"We want a spineless cactus pear that will grow fast and produce a lot of biomass," Cushman said.

One of the other goals of the project is to learn more about Opuntia stunting disease, which causes cactuses to grow smaller pads and fruit. The team is taking samples from the infected plants to look at the DNA and RNA to find what causes the disease and how it

is transferred to other cactuses in the field. The hope is to use the information to create a diagnostic tool and treatment to detect and prevent the disease's spread and to salvage usable parts from diseased plants.

Research identifies impact of teenage screen use

Date: March 5, 2021
Source: University of Leicester
Summary: Two thirds of children use more than one screen at the same time after school, in the evenings and at weekends as part of increasingly sedentary lifestyles, according to new research.

An NIHR study of more than 800 adolescent girls between the ages of 11 and 14 identified worrying trends between screen use and lower physical activity — including higher BMI — as well as less sleep.

The use of concurrent screens (termed 'screen stacking') grew over the course of the week — with 59 per cent of adolescents using two or more screens after school, 65 per cent in the evenings, and 68 per cent at weekends.

Some teens reporting using as many as four screens at one time.

But further analysis showed the use of any screen was still detrimental to the indicators of health and wellbeing. More than 90 per cent owned or had access to a smart phone and using this after school had a knock on effect on their sleep.

Researchers from the Leicester Diabetes Centre at the University measured physical activity and sleep using accelerometers worn on participants' wrists, while those involved in the study self-reported the number of screens they were using at the same time — such as scrolling on a mobile phone while also watching TV — as well as perceptions of self-esteem and physical self-worth.

Dr Deirdre Harrington, Lecturer in Physical Activity for Health led the study during her time at Leicester and now works in the School of Psychological Sciences and Health at the University of Strathclyde. She said:

"Intuitively, we believe there must be negative effects on teenagers of using too many screens at the same time. Our data show it isn't as simple as that.

"This research was done before the COVID-19 lockdown, where much more of our day is spent in front of a screen. More than ever the effects of this on adolescents need to be known — there are positives too, no doubt.

"These adolescents wore an accelerometer 24 hours a day for a week allowing us to capture their daily routines and even estimate their sleep. Uniquely, they also reported how many screens they used at the same time which is not well known."

Melanie Davies, Professor of Diabetes Medicine at the University of Leicester and Co-Director of the Leicester Diabetes Centre based at Leicester General Hospital, said:

"Sadly, this study reminds us that we are in danger of creating a new generation of sedentary children. Increased sedentary time is closely linked to type 2 diabetes, which is increasing in younger age groups.

"The number of young people with type 2 diabetes has gone up by 50 per cent in just five years."

The study was supported by the National Institute for Public Health Research programme as well as the NIHR Leicester Biomedical Research Centre, and the NIHR Applied Research and Care (ARC) East Midlands.

Artificial intelligence reveals current drugs that may help combat Alzheimer's disease

Analysis points to new treatment targets for the disease
Date: March 4, 2021
Source: Massachusetts General Hospital
Summary: Researchers have developed a method based on artificial intelligence that rapidly identifies currently available medications that may treat Alzheimer's disease. The method also reveals potential new treatment targets for the disease.

New treatments for Alzheimer's disease are desperately needed, but numerous clinical trials of investigational drugs have failed to generate promising options. Now a team at Massachusetts General Hospital (MGH) and Harvard Medical School (HMS) has developed an artificial intelligence-based method to screen currently available medications as possible treatments for Alzheimer's disease. The method could represent a rapid and inexpensive way to repurpose existing therapies into new treatments for this progressive, debilitating neurodegenerative condition. Importantly, it could also help reveal new, unexplored targets for therapy by pointing to mechanisms of drug action.

"Repurposing FDA-approved drugs for Alzheimer's disease is an attractive idea that can help accelerate the arrival of effective treatment — but unfortunately, even for previously approved drugs, clinical trials require substantial resources, making it impossible to evaluate every drug in patients with Alzheimer's disease," explains Artem Sokolov, PhD, director of Informatics and Modeling at the Laboratory of Systems Pharmacology at HMS. "We therefore built a framework for prioritizing drugs, helping clinical studies to focus on the most promising ones."

In an article published in Nature Communications, Sokolov and his colleagues describe their framework, called DRIAD (Drug Repurposing In Alzheimer's Disease), which relies on machine learning — a branch of artificial intelligence in which systems are "trained" on vast amounts of data, "learn" to identify telltale patterns and augment researchers' and clinicians' decision-making.

DRIAD works by measuring what happens to human brain neural cells when treated with a drug. The method then determines whether the changes induced by a drug correlate with molecular markers of disease severity.

The approach also allowed the researchers to identify drugs that had protective as well as damaging effects on brain cells.

"We also approximate the directionality of such correlations, helping to identify and filter out neurotoxic drugs that accelerate neuronal death instead of preventing it," says co-first author Steve Rodriguez, PhD, an investigator in the Department of Neurology at MGH and an instructor at HMS.

DRIAD also allows researchers to examine which proteins are targeted by the most promising drugs and if there are common trends among the targets, an approach

designed by Clemens Hug, PhD, a research associate in the Laboratory of Systems Pharmacology and a co-first author.

The team applied the screening method to 80 FDA-approved and clinically tested drugs for a wide range of conditions. The analysis yielded a ranked list of candidates, with several anti-inflammatory drugs used to treat rheumatoid arthritis and blood cancers emerging as top contenders. These drugs belong to a class of medications known as Janus kinase inhibitors. The drugs work by blocking the action of inflammation-fueling Janus kinase proteins, suspected to play a role in Alzheimer's disease and known for their role in autoimmune conditions. The team's analyses also pointed to other potential treatment targets for further investigation.

"We are excited to share these results with the academic and pharmaceutical research communities. Our hope is that further validation by other researchers will refine the prioritization of these drugs for clinical investigation," says Mark Albers, MD, PhD, the Frank Wilkins Jr. and Family Endowed Scholar and associate director of the Massachusetts Center for Alzheimer Therapeutic Science at MGH and a faculty member of the Laboratory of Systems Pharmacology at HMS. One of these drugs, baricitinib, will be investigated by Albers in a clinical trial for patients with subjective cognitive complaints, mild cognitive impairment, and Alzheimer's disease that will be launching soon at MGH in Boston and at Holy Cross Health in Fort Lauderdale, Florida. "In addition, independent validation of the nominated drug targets could provide new insights into the mechanisms behind Alzheimer's disease and lead to novel therapies," says Albers.

This work was supported by the National Institute on Aging, the CART fund and the Harvard Catalyst Program for Faculty Development and Diversity Inclusion.

New generation of tiny, agile drones introduced

The technology could boost aerial robots' repertoire, allowing them to operate in cramped spaces and withstand collisions
Date: March 3, 2021
Source: Massachusetts Institute of Technology
Summary: Researchers developed an insect-size drone with soft actuators — akin to muscles — that are agile and resilient to collisions. The advance could boost aerial robots' repertoire, allowing them to operate in cramped spaces and withstand collisions.

The technology could boost aerial robots' repertoire, allowing them to operate in cramped spaces and withstand collisions

If you've ever swatted a mosquito away from your face, only to have it return again (and again and again), you know that insects can be remarkably acrobatic and resilient in flight. Those traits help them navigate the aerial world, with all of its wind gusts, obstacles, and general uncertainty. Such traits are also hard to build into flying robots, but MIT Assistant Professor Kevin Yufeng Chen has built a system that approaches insects' agility.

Chen, a member of the Department of Electrical Engineering and Computer Science and the Research Laboratory of Electronics, has developed insect-sized drones with unprecedented dexterity and resilience. The aerial robots are powered by a new class of soft actuator, which allows them to withstand

the physical travails of real-world flight. Chen hopes the robots could one day aid humans by pollinating crops or performing machinery inspections in cramped spaces.

Chen's work appears this month in the journal IEEE Transactions on Robotics. His co-authors include MIT PhD student Zhijian Ren, Harvard University PhD student Siyi Xu, and City University of Hong Kong roboticist Pakpong Chirarattananon.

Typically, drones require wide open spaces because they're neither nimble enough to navigate confined spaces nor robust enough to withstand collisions in a crowd. "If we look at most drones today, they're usually quite big," says Chen. "Most of their applications involve flying outdoors. The question is: Can you create insect-scale robots that can move around in very complex, cluttered spaces?"

According to Chen, "The challenge of building small aerial robots is immense." Pint-sized drones require a fundamentally different construction from larger ones. Large drones are usually powered by motors, but motors lose efficiency as you shrink them. So, Chen says, for insect-like robots "you need to look for alternatives."

The principal alternative until now has been employing a small, rigid actuator built from piezoelectric ceramic materials. While piezoelectric ceramics allowed the first generation of tiny robots to take flight, they're quite fragile. And that's a problem when you're building a robot to mimic an insect — foraging bumblebees endure a collision about once every second.

Chen designed a more resilient tiny drone using soft actuators instead of hard, fragile ones. The soft actuators are made of thin rubber cylinders coated in carbon nanotubes. When voltage is applied to the carbon nanotubes, they produce an electrostatic force that squeezes and elongates the rubber cylinder. Repeated elongation and contraction causes the drone's wings to beat — fast.

Chen's actuators can flap nearly 500 times per second, giving the drone insect-like resilience. "You can hit it when it's flying, and it can recover," says Chen. "It can also do aggressive maneuvers like somersaults in the air." And it weighs in at just 0.6 grams, approximately the mass of a large bumble bee. The drone looks a bit like a tiny cassette tape with wings, though Chen is working on a new prototype shaped like a dragonfly.

Building insect-like robots can provide a window into the biology and physics of insect flight, a longstanding avenue of inquiry for researchers. Chen's work addresses these questions through a kind of reverse engineering. "If you want to learn how insects fly, it is very instructive to build a scale robot model," he says. "You can perturb a few things and see how it affects the kinematics or how the fluid forces change. That will help you understand how those things fly." But Chen aims to do more than add to entomology textbooks. His drones can also be useful in industry and agriculture.

Chen says his mini-aerialists could navigate complex machinery to ensure safety and functionality. "Think about the inspection of a turbine engine. You'd want a drone to move around [an enclosed space] with a small camera to check for cracks on the turbine plates."

Other potential applications include artificial pollination of crops or completing search-and-rescue missions following a disaster.

"All those things can be very challenging for existing large-scale robots," says Chen. Sometimes, bigger isn't better.

New crystalline form of ice

New crystalline form of ice

Scientists elucidate crystal structure for exotic ice XIX
Date: February 18, 2021
Source University of Innsbruck
Summary: Three years ago, chemists found evidence for the existence of a new variety of ice. Until then, 18 types of crystalline ice were known. The team now reports on the elucidation of the crystal structure of ice XIX using neutron diffraction.

Scientists elucidate crystal structure for exotic ice XIX

Three years ago, chemists found evidence for the existence of a new variety of ice. Until then, 18 types of crystalline ice were known. The team now reports on the elucidation of the crystal structure of ice XIX using neutron diffraction.

Ice is a very versatile material. In snowflakes or ice cubes, the oxygen atoms are arranged hexagonally. This ice form is called ice one (ice I). "Strictly speaking, however, these are not actually perfect crystals, but disordered systems in which the water molecules are randomly oriented in different spatial directions," explains Thomas Loerting from the Institute of Physical Chemistry at the University of Innsbruck, Austria. Including ice I, 18 crystalline forms of ice were known so far, which differ in the arrangement of their atoms. The different types of ice, known as polymorphs, form depending on pressure and temperature and have very different properties. For example, their melting points differ by several hundred degrees Celsius. "It's comparable to diamond and graphite, both of which are made of pure carbon," the chemist explains.

Icy variety

When conventional ice I is cooled strongly, the hydrogen atoms can arrange themselves periodically in addition to the oxygen atoms if the experiment is conducted correctly. Below minus 200 degrees Celsius, this can lead to the formation of so-called ice XI, in which all water molecules are ordered according to a specific pattern. Such ordered ice forms differ from the disordered parental forms, especially in their electrical properties. In the current work, the Innsbruck chemists deal with the parent form ice VI, which is formed at high pressure, for example in the Earth's mantle. Like hexagonal ice, this high-pressure form of ice is not a completely ordered crystal. More than 10 years ago, researchers at the University of Innsbruck produced a hydrogen-ordered variant of this ice, which found its way into textbooks as ice XV. By changing the manufacturing process, three years ago Thomas Loerting's team succeeded for the first time in creating a second ordered form for ice VI. To do this, the scientists significantly slowed down the cooling process and increased the pressure to around 20 kbar. This enabled them to arrange the hydrogen atoms in a second way in the oxygen lattice and produce ice XIX. "We found clear evidence at that time that it is a new ordered variant, but we were not able to elucidate the crystal structure." Now his team

has succeeded in doing just that using the gold standard for structure determination — neutron diffraction.

Crystal structure solved

For the clarification of the crystal structure, an essential technical hurdle had to be overcome. In an investigation using neutron diffraction, it is necessary to replace the light hydrogen in water with deuterium ("heavy hydrogen"). "Unfortunately, this also changes the time scales for ordering in the ice manufacturing process," says Loerting. "But Ph.D. student Tobias Gasser then had the crucial idea of adding a few percent of normal water to the heavy water — which turned out to speed up the ordering immensely." With the ice obtained in this way, the Innsbruck scientists were finally able to measure neutron data on the high-resolution HRPD instrument at the Rutherford Appleton Laboratory in England and painstakingly solve the crystal structure of ice XIX. This required finding the best crystal structure out of several thousand candidates from the measured data — much like searching for a needle in a haystack. A Japanese research group confirmed the Innsbruck result in another experiment under different pressure conditions. Both papers have now been published jointly in Nature Communications.

Six ice forms discovered in Innsbruck

While conventional ice and snow are abundant on Earth, no other forms are found on the surface of our planet — except in research laboratories. However, the high-pressure forms ice VI and ice VII are found as inclusions in diamonds and have therefore been added to the list of minerals by the International Mineralogical Association (IMA). Many varieties of water ice are formed in the vastness of space under special pressure and temperature conditions. They are found, for example, on celestial bodies such as Jupiter's moon Ganymede, which is covered by layers of different ice varieties.

Ice XV and ice XIX represents the first sibling pair in ice physics in which the oxygen lattice is the same, but the pattern how hydrogen atoms are ordered is different. "This also means that for the first time it will now be possible to realize the transition between two ordered ice forms in experiments," Thomas Loerting is pleased to report. Since the 1980s, researchers at the University of Innsbruck, Austria, are now responsible for the discovery of four crystalline as well as two amorphous ice forms.

The current research work was carried out within the framework of the Research Platform for Materials and Nanoscience at the University of Innsbruck and was financially supported by the Austrian Science Fund FWF.

Silicon anode structure generates new potential for lithium-ion batteries

Date: February 8, 2021
Source: Okinawa Institute of Science and Technology (OIST) Graduate University
Summary: New research has identified a nanostructure that improves the anode in lithium-ion batteries. Instead of using graphite for the anode, the researchers turned to silicon: a material that stores more charge but is susceptible to fracturing. The team deposited silicon atoms on top of metallic nanoparticles to form an arched nanostructure, increasing the strength and structural integrity of the anode. Electrochemical tests showed the batteries

had a higher charge capacity and longer lifespan.

New research conducted by the Okinawa Institute of Science and Technology Graduate University (OIST) has identified a specific building block that improves the anode in lithium-ion batteries. The unique properties of the structure, which was built using nanoparticle technology, are revealed and explained today in Communications Materials.

Powerful, portable and rechargeable, lithium-ion batteries are crucial components of modern technology, found in smartphones, laptops and electric vehicles. In 2019, their potential to revolutionize how we store and consume power in the future, as we move away from fossil fuels, was notably recognized, with the Nobel Prize co-awarded to new OIST Board of Governors member, Dr. Akira Yoshino, for his work developing the lithium-ion battery.

Traditionally, graphite is used for the anode of a lithium-ion battery, but this carbon material has major limitations.

"When a battery is being charged, lithium ions are forced to move from one side of the battery — the cathode — through an electrolyte solution to the other side of the battery — the anode. Then, when a battery is being used, the lithium ions move back into the cathode and an electric current is released from the battery," explained Dr. Marta Haro, a former researcher at OIST and first author of the study. "But in graphite anodes, six atoms of carbon are needed to store one lithium ion, so the energy density of these batteries is low."

With science and industry currently exploring the use of lithium-ion batteries to power electric vehicles and aerospace craft, improving energy density is critical. Researchers are now searching for new materials that can increase the number of lithium ions stored in the anode.

One of the most promising candidates is silicon, which can bind four lithium ions for every one silicon atom.

"Silicon anodes can store ten times as much charge in a given volume than graphite anodes — a whole order of magnitude higher in terms of energy density," said Dr. Haro. "The problem is, as the lithium ions move into the anode, the volume change is huge, up to around 400 per cent, which causes the electrode to fracture and break."

The large volume change also prevents stable formation of a protective layer that lies between the electrolyte and the anode. Every time the battery is charged, this layer therefore must continually reform, using up the limited supply of lithium ions and reducing the lifespan and rechargeability of the battery.

"Our goal was to try and create a more robust anode capable of resisting these stresses, that can absorb as much lithium as possible and ensure as many charge cycles as possible before deteriorating," said Dr. Grammatikopoulos, senior author of the paper. "And the approach we took was to build a structure using nanoparticles."

In a previous paper, published in 2017 in Advanced Science, the now-disbanded OIST Nanoparticles by Design Unit developed a cake-like layered structure, where each layer of silicon was sandwiched between tantalum metal nanoparticles. This improved the structural integrity of the silicon anode, preventing over-swelling.

While experimenting with different thicknesses of the silicon layer to see how it affected the material's elastic properties, the researchers noticed something strange.

"There was a point at a specific thickness of the silicon layer where the elastic properties of the structure completely changed," said Theo Bouloumis, a current PhD student at OIST who was conducting this experiment. "The material became gradually stiffer, but then quickly decreased in stiffness when the thickness of the silicon layer was further increased. We had some ideas, but at the time, we didn't know the fundamental reason behind why this change occurred."

Now, this new paper finally provides an explanation for the sudden spike in stiffness at one critical thickness.

Through microscopy techniques and computer simulations at the atomic level, the researchers showed that as the silicon atoms are deposited onto the layer of nanoparticles, they don't form an even and uniform film. Instead, they form columns in the shape of inverted cones, growing wider and wider as more silicon atoms are deposited. Eventually, the individual silicon columns touch each other, forming a vaulted structure.

"The vaulted structure is strong, just like an arch is strong in civil engineering," said Dr. Grammatikopoulos. "The same concept applies, just on a nanoscale."

Importantly, the increased strength of the structure also coincided with enhanced battery performance. When the scientists carried out electrochemical tests, they found that the lithium-ion battery had an increased charge capacity. The protective layer was also more stable, meaning the battery could withstand more charge cycles.

These improvements are only seen at the precise moment that the columns touch. Before this moment occurs, the individual pillars are wobbly and so cannot provide structural integrity to the anode. And if silicon deposition continues after the columns touch, it creates a porous film with many voids, resulting in a weak, sponge-like behavior.

This reveal of the vaulted structure and how it gains its unique properties not only acts as an important step forward towards the commercialization of silicon anodes in lithium-ion batteries, but also has many other potential applications within material sciences.

"The vaulted structure could be used when materials are needed that are strong and able to withstand various stresses, such as for bio-implants or for storing hydrogen," said Dr. Grammatikopoulos. "The exact type of material you need — stronger or softer, more flexible or less flexible — can be precisely made, simply by changing the thickness of the layer. That's the beauty of nanostructures."

Discoveries at the edge of the periodic table: First ever measurements of einsteinium

Experiments scientists on this highly radioactive element reveal some unexpected properties
Date: February 6, 2021
Source: Lawrence Berkeley National Laboratory
Summary: Since element 99 — einsteinium — was discovered in 1952 from the debris of the first hydrogen bomb, scientists have

performed very few experiments with it because it is so hard to create and is exceptionally radioactive. A team of chemists has overcome these obstacles to report the first study characterizing some of its properties, opening the door to a better understanding of the remaining transuranic elements of the actinide series.

Since element 99 — einsteinium — was discovered in 1952 at the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) from the debris of the first hydrogen bomb, scientists have performed very few experiments with it because it is so hard to create and is exceptionally radioactive.A team of Berkeley Lab chemists has overcome these obstacles to report the first study characterizing some of its properties, opening the door to a better understanding of the remaining transuranic elements of the actinide series.

Published in the journal Nature, the study,"Structural and Spectroscopic Characterization of an Einsteinium Complex,"was co-led by Berkeley Lab scientist Rebecca Abergel and Los Alamos National Laboratory scientist Stosh Kozimor, and included scientists from the two laboratories, UC Berkeley, and Georgetown University, several of whom are graduate students and postdoctoral fellows. With less than 250 nanograms of the element, the team measured the first-ever einsteinium bond distance, a basic property of an element's interactions with other atoms and molecules.

"There's not much known about einsteinium," said Abergel,who leads Berkeley Lab'sHeavy Element Chemistry groupand is an assistant professor in UC Berkeley's Nuclear Engineering department. "It's a remarkable achievement that we were able to work with this small amount of material and do inorganic chemistry. It's significant because the more we understand about its chemical behavior, the more we can apply this understanding for the development of new materials or new technologies, not necessarily just with einsteinium, but with the rest of the actinides too. And we can establish trends in the periodic table."

Short-lived and hard to make

Abergel and her team used experimental facilities not available decades ago when einsteinium was first discovered the Molecular Foundryat Berkeley Lab and theStanford Synchrotron Radiation Lightsource (SSRL) at SLAC National Accelerator Laboratory, both DOE Office of Science user facilities — to conduct luminescence spectroscopy and X-ray absorption spectroscopy experiments.

But first, getting the sample in a usable form was almost half the battle. "This whole paper is a long series of unfortunate events," she said wryly.

The material was made at Oak Ridge National Laboratory's High Flux Isotope Reactor, one of only a few places in the world that is capable of making einsteinium, which involves bombarding curium targets with neutrons to trigger a long chain of nuclear reactions. The first problem they encountered was that the sample was contaminated with a significant amount of californium, as making pure einsteinium in a usable quantity is extraordinarily challenging.

So they had to scrap their original plan to use X-ray crystallography — which is considered the gold standard for obtaining

structural information on highly radioactive molecules but requires a pure sample of metal — and instead came up with a new way to make samples and leverage element-specific research techniques. Researchers at Los Alamos provided critical assistance in this step by designing a sample holder uniquely suited to the challenges intrinsic to einsteinium.

Then, contending with radioactive decay was another challenge. The Berkeley Lab team conducted their experiments with einsteinium-254, one of the more stable isotopes of the element. It has a half-life of 276 days, which is the time for half of the material to decay. Although the team was able to conduct many of the experiments before the coronavirus pandemic, they had plans for follow-up experiments that got interrupted thanks to pandemic-related shutdowns. By the time they were able to get back into their lab last summer, most of the sample was gone.

Bond distance and beyond

Still, the researchers were able to measure a bond distance with einsteinium and also discovered some physical chemistry behavior that was different from what would be expected from the actinide series, which are the elements on the bottom row of the periodic table.

"Determining the bond distance may not sound interesting, but it's the first thing you would want to know about how a metal binds to other molecules. What kind of chemical interaction is this element going to have with other atoms and molecules?" Abergel said.

Once scientists have this picture of the atomic arrangement of a molecule that incorporates einsteinium, they can try to find interesting chemical properties and improve understanding of periodic trends. "By getting this piece of data, we gain a better, broader understanding of how the whole actinide series behaves. And in that series, we have elements or isotopes that are useful for nuclear power production or radiopharmaceuticals," she said.

Tantalizingly, this research also offers the possibility of exploring what is beyond the edge of the periodic table, and possibly discovering a new element. "We're really starting to understand a little better what happens toward the end of the periodic table, and the next thing is, you could also envision an einsteinium target for discovering new elements," Abergel said. "Similar to the latest elements that were discovered in the past 10 years, like tennessine, which used a berkelium target, if you were to be able to isolate enough pure einsteinium to make a target, you could start looking for other elements and get closer to the (theorized) island of stability," where nuclear physicists have predicted isotopes may have half-lives of minutes or even days, instead of the microsecond or less half-lives that are common in the superheavy elements.

Study co-authors were Korey Carter, Katherine Shield, Kurt Smith, Leticia Arnedo-Sanchez, Tracy Mattox, Liane Moreau, and Corwin Booth of Berkeley Lab; Zachary Jones and Stosh Kozimor of Los Alamos National Laboratory; and Jennifer Wacker and

Karah Knope of Georgetown University. The research was supported by the DOE Office of Science.

Human activity forces animals to move 70% further to survive

World-first study shows episodic human events trigger animal movement
Date: February 1, 2021
Source: University of Sydney
Summary: Scientists have analysed for the first time the amount by which human activity forces animals to alter their movements. What's surprising is that episodic activity - like hunting, oil pipeline construction, military manoeuvres - seem to have the biggest impact.

For the first time, scientists have calculated the global impact of human activity on animal movement, revealing widespread impacts that threaten species survival and biodiversity.

While it has been shown that activities such as logging and urbanisation can have big impacts on wildlife, the study by scientists at the University of Sydney and Deakin University in Australia shows that episodic events such as hunting, military activity and recreation can trigger even bigger changes in animal behaviour.

"It is vital we understand the scale of impact that humans have on other animal species," said lead author Dr Tim Doherty, a wildlife ecologist at the University of Sydney. "The consequences of changed animal movement can be profound and lead to reduced animal fitness, lower chances of survival, reduced reproductive rates, genetic isolation and even local extinction."

The study is published today in Nature Ecology & Evolution.

Key findings include:

- Changes in animal movement in response to disturbance are common

- Episodic human activities such as hunting, aircraft use, military activity and recreation can cause much greater increases in movement distances than habitat modification such as logging or agriculture

- Episodic disturbances force a 35 per cent overall change in movement (increase and decrease); habitat modifications force a 12 per cent change

- Increases in animal movement averaged 70 per cent

- Decreases in animal movement averaged 37 per cent

The study points to a global restructuring of animal movements caused by human disturbance, with potentially profound impacts on animal populations, species and ecosystem processes.

"Movement is critical to animal survival, but it can be disrupted by human disturbances," Dr Doherty said. "Animals adopt behavioural mechanisms to adjust to human activity, such as by fleeing or avoiding humans, travelling further to find food or mates; or finding new shelter to avoid humans or predators."

In some cases, human activity forced a reduction in animal movement, the study found, because of increased access to food in human locations, reduced ability to move from modified habitat or restrictions to movement by physical barriers.

"As well as the direct impact on animal species, there are knock-on effects," Dr Doherty said. "Animal movement is linked to important ecological processes such as pollination, seed dispersal and soil turnover, so disrupted animal movement can have negative impacts throughout ecosystems."

Policy Implications

Dr Doherty, who started this research at Deakin University before moving to the University of Sydney, has said the findings have important policy implications for managing animal biodiversity.

"In marine environments and landscapes relatively untouched by human impact, it is important that habitat modification is avoided," said Dr Doherty from the School of Life and Environmental Sciences in the Faculty of Science.

"This could involve strengthening and supporting existing protected areas and securing more areas of wilderness for legal protection."

The study says it might be easier to reduce the impacts of episodic disturbances by carefully managing certain activities, such as hunting and tourism, in wilderness areas, especially during animal breeding periods.

"Where habitat modification is unavoidable, we recommend that knowledge of animal movement behaviour informs landscape design and management to ensure animal movement is secured," Dr Doherty said.

He said that reducing negative impacts of human activity on animal movement will be vital for securing biodiversity in an increasingly human-dominated world.

"Further research is needed to better understand the impact of habitat modification on animal movement in rapidly developing parts of the world," Dr Doherty said.

The research compiled and analysed 208 separate studies on 167 animal species over 39 years to assess how human disturbance influences animal movement. In more than one-third of cases, animals were forced into changes that saw movement increase by more than 50 per cent.

Species covered in the study range from the 0.05 gram sleepy orange butterfly to the more than 2000 kilogram great white shark. There were 37 bird species, 77 mammal species, 17 reptile species, 11 amphibian species, 13 fish species and 12 arthropod (insect) species covered.

Toddlers who use touchscreens may be more distractible

Date: January 26, 2021
Source: University of Bath
Summary: New research highlights some of the effects regular use of touchscreens might have on toddlers.

Toddlers with high daily touchscreen use are quicker to look at objects when they appear and are less able to resist distraction compared to toddlers with no or low touchscreen use — according to new research from Birkbeck, University of London, King's College London and University of Bath.

The research team say the findings are important for the growing debate around the

role of screen time on toddlers' development especially given the increased levels of screen time seen during the COVID-19 pandemic.

Lead researcher Professor Tim Smith, from Birkbeck's Centre for Brain and Cognitive Development, said: "The use of smartphones and tablets by babies and toddlers has accelerated rapidly in recent years. The first few years of life are critical for children to learn how to control their attention and ignore distraction, early skills that are known to be important for later academic achievement. There has been growing concern that toddler touchscreen use may negatively impact their developing attention but previously there was no empirical evidence to support this."

To provide such evidence, Professor Smith's TABLET Project, at Birkbeck's Centre for Brain and Cognitive Development, recruited 12-month-old infants who had different levels of touchscreen usage. The study followed them over the next 2.5 years, bringing them into the lab three times, at 12 months, 18 months and 3.5 years. During each visit the toddlers took part in computer tasks with an eye-tracker to measure their attention. Objects appeared in different screen locations. How quickly toddlers looked at the objects and how well they could ignore distracting objects were measured.

Professor Smith states: "We found that infants and toddlers with high touchscreen use were faster to look at objects when they appeared and were less able to ignore distracting objects compared to the low users."

Dr Ana Maria Portugal, main researcher on the project points out "We are currently unable to conclude that the touchscreen use caused the differences in attention as it could also be that children who are more distractible may be more attracted to the attention-grabbing features of touchscreen devices than those who are not."

Co-investigator Dr Rachael Bedford, from the Department of Psychology at University of Bath commented: "What we need to know next is how this pattern of increased looking to distracting objects on screens relates to attention in the real-world: is it a positive sign that the children have adapted to the multitasking demands of their complex everyday environment or does it relate to difficulties during tasks that require concentration?"

Sport may fast-track numeracy skills for indigenous children

Date: January 25, 2021
Source: University of South Australia
Summary: Greater sports participation among Aboriginal and Torres Strait Islander children is linked with better academic performance, according to new research from the University of South Australia.

Greater sports participation among Aboriginal and Torres Strait Islander children is linked with better academic performance, according to new research from the University of South Australia.

Conducted in partnership with the University of Sydney and the University of Technology Sydney, the world-first study found that Aboriginal and Torres Strait Islander children who played organised sports every year over four years, had numeracy skills which were advanced by seven months, compared to children who did less sport.

The study used data from four successive waves of Australia's Longitudinal Study of Indigenous Children, following 303 students (with a baseline age of five to six years old) to assess cumulative sports participation against academic performance in standardised NAPLAN and PAT outcomes.

Sports participation has been linked with better cognitive function and memory in many child populations, but this is the first study to confirm the beneficial association between ongoing involvement in sport and academic performance among Aboriginal and Torres Strait Islander children.

Lead researcher, UniSA's Dr Dot Dumuid, says the study highlights the importance of sports as a strategy to help close the gap* for Australia's first nations peoples.

"Playing sport has always had strong cultural importance to Aboriginal and Torres Strait Islanders, so understanding how sports can boost numeracy among Indigenous children is a valuable step towards improving health and reducing disadvantage," Dr Dumuid says.

"When children play sport, they're learning the social structures of a team, how to work within rules, how to focus their attention, and key strategies for success.

"Interestingly, when children play sport, they're not only activating parts of the brain that are involved in learning, but they're also inadvertently practising mathematical computations such as 'how much time is left in the game?' and 'how many points do we need to win?', and it's this that may well be contributing to improved numeracy."

Aboriginal and Torres Strait Islanders comprise a relatively large proportion of athletes in Australia's leading sports teams. While only representing about three per cent of the population, they make up nine per cent of AFL players, and 22 per cent of State of Origin players.

Encouraging sports in Aboriginal and Torres Strait Islander communities could have many other benefits for health and wellbeing, says co-researcher and Professor of Indigenous Health Education at UTS, John Evans.

"Playing sport creates a sense of belonging, and builds self-esteem, coherence and purpose," Professor Evans says.

"This is especially important for people living in rural and remote areas where opportunities for social interaction and structured activities can be limited.

"If we can find ways to encourage greater participation among Aboriginal and Torres Strain Islander communities, while removing key barriers — such as financial costs and lack of transport — we could promote healthier living, more cohesive societies while also and boosting academic performance among Indigenous children."

A new material for separating CO_2 from industrial waste gases, natural gas, or biogas

Date: October 20, 2020
Source: Universität Bayreuth
Summary: With a new material, the greenhouse gas carbon dioxide (CO_2) can be specifically separated from industrial waste gases, natural gas, or biogas, and thereby made available for recycling. The separation process is both energy efficient and cost-effective.

Chemists at the University of Bayreuth have developed a material that could well make an important contribution to climate protection and sustainable industrial production. With this material, the greenhouse gas carbon dioxide (CO_2) can be specifically separated from industrial waste gases, natural gas, or biogas, and thereby made available for recycling. The separation process is both energy efficient and cost-effective. In the journal Cell Reports Physical Science the researchers present the structure and function of the material.

The "Green Deal," presented by the European Commission in 2019, calls for the net emissions of greenhouse gases within the EU to be reduced to zero by 2050. This requires innovative processes that can separate and retain CO_2 from waste gases and other gas mixtures so that it is not released into the atmosphere. The material developed in Bayreuth has one fundamental advantage over previous separation processes: It is capable of completely removing CO_2 from gas mixtures without chemically binding CO_2. These gas mixtures can be waste gases from industrial plants, but also natural gas or biogas. In all these cases, CO_2 accumulates in the cavities of the material solely due to physical interaction. From there, it can be released without great expenditure of energy, to be made available again as a resource for industrial production. Hence, the separation process works, chemically speaking, according to the principle of physical adsorption. Like a spacious storage tank, the new material can be filled with and emptied of carbon dioxide in an energy-efficient way. In Bayreuth laboratories, it was designed in such a way as to only separate out CO_2 and no other gas from the most varied gas mixtures.

"Our research team has succeeded in designing a material that fulfils two tasks at the same time. On the one hand, the physical interactions with CO_2 are strong enough to free and retain this greenhouse gas from a gas mixture. On the other hand, however, they are weak enough to allow the release of CO_2 from the material with only a small amount of energy," says Martin Riess M.Sc., first author of the new publication and doctoral researcher at the Inorganic Chemistry I research group at the University of Bayreuth.

The new material is an inorganic-organic hybrid. The chemical basis is clay minerals consisting of hundreds of individual glass platelets. These are only one nanometre thick each, and arranged precisely one above the other. Between the individual glass plates there are organic molecules that act as spacers. Their shape and chemical properties have been selected so that the pore spaces created are optimally tailored to accumulate CO_2. Only carbon dioxide molecules can penetrate into the pore system of the material and be retained there. In contrast, methane, nitrogen, and other exhaust gas components must remain outside due to the size of their molecules. The researchers have used the so-called molecular sieve effect to increase the material's selectivity for CO_2. They are currently working on the development of a membrane system based on clay minerals, designed to allow the continuous, selective, and energy-efficient separation of CO_2 from gas mixtures.

The development of a hybrid material tailor-made for the separation and supply of CO_2 was made possible thanks to a special measuring system set up in the Bayreuth laboratories which allows the precise determination of quantities of adsorbed

gases and of the selectivity of the adsorbing material. This has enabled industrial processes to be reproduced realistically. "All criteria relevant to the evaluation of industrial CO_2 separation processes have been completely fulfilled by our hybrid material. It can be produced cost-effectively, and stands to make an important contribution to reducing industrial carbon dioxide emissions, but also to the processing of biogas and acidic natural gas," says Martin Riess.

Lullabies in any language relax babies

Date: October 19, 2020
Source: Harvard University
Summary: Researchers have determined that American infants relaxed when played lullabies that were unfamiliar and in a foreign language. The new findings supported the latter hypothesis: infants responded to universal elements of songs, despite the unfamiliarity of their melodies and words, and relaxed. The researchers also predict that the results could be replicated with a different group of subjects from another culture.

Virtually all new parents quickly discover that a lullaby will in fact help an infant unwind, but they might surprised to learn that babies aren't fussy about the language.

Researchers at Harvard's Music Lab have determined that American infants relaxed when played lullabies that were unfamiliar and in a foreign language. Their results were published in Nature Human Behaviour Oct. 19.

"There's a longstanding debate about how music affects listeners as a result of both prior experiences with music and the basic design of our psychology," said Samuel Mehr, a Department of Psychology Research Associate and Principal Investigator at the Music Lab. "Common sense tells us that infants find the lullabies they hear relaxing. Is this just because they've experienced their parents' singing before and know it means they're safe and secure? Or is there also something universal about lullabies that produces these effects, independently of experience?"

The new findings supported the latter hypothesis: Infants responded to universal elements of songs, despite the unfamiliarity of their melodies and words, and relaxed. The study was conducted in 2018 and 2019 at the Music Lab, which focuses on the psychology of music from infancy to adulthood.

In the experiment, each infant watched an animated video of two characters singing either a lullaby or a non-lullaby. To measure the infants' relaxation responses to the recordings, the researchers focused on pupil dilation, heart rate changes, electrodermal (a measure of "arousal" or excitement, from electrical resistance of the skin), frequency of blinking, and gaze direction as indicators of relaxation or agitation. Generally, the infants experienced a decrease in heart rate and pupil dilation, and attenuated electrodermal activity in response to the unfamiliar lullabies.

The researchers had to act quickly because of the limited attention spans of their subjects; most babies could pay attention for about five minutes before getting distracted.

"In an ideal world, we would play babies a dozen songs that are lullabies and a dozen songs that are not lullabies and gather a

lot of data from each infant. But an infant's attention span is short, so the experiment is short too," said Mila Bertolo, co-first author of the research.

The songs were chosen through a previous Music Lab study, in which adults rated how likely a foreign unfamiliar song was to be a lullaby, a dance song, a healing song, or a love song. Using a cross-cultural sample of adult-rated lullabies helped the researchers avoid incorporating their own selection bias into the process, where they might be more inclined to choose songs that most closely resembled a western lullaby, said Bertolo.

The 16 songs selected for the experiment came from the Natural History of Song Discography, and included lullabies and other songs originally produced to express love, heal the sick, or encourage dancing. Languages like Scottish Gaelic, Hopi, and Western Nahuatl, and regions including Polynesia, Central America, and the Middle East were represented in the songs chosen.

"Melody is one of the things that sticks out for lullabies. In comparison, in a lot of other song types, such as dance songs, you would see rhythm as being more of a driving force," explained Connie Bainbridge, who co-led the research with Bertolo in the Music Lab, and is now pursuing a Ph.D. in communication at UCLA.

Separately, researchers asked parents to listen to both types of song and choose which they would use to soothe their infant. They almost always chose the lullaby, indicating that they also recognized the universal elements of the lullaby, even subconsciously. "Calming a fussy infant is an urgent matter for parents. Those of us with kids might be particularly sensitive to the acoustic features that appear universally in lullabies, as these may be most likely to calm our infants efficiently," said Mehr.

The findings are "a testament to how effective music is," said Bertolo. "This piece of the puzzle helps us make sense of certain kind of downstream effects" like music therapy in clinical settings. "It's an interesting question to see whether the same thing that drives the relaxation for infants would carry through into adulthood."

The researchers predict that the results could be replicated with a different group of subjects from another culture. They also plan to continue investigating questions raised during the experiment, such as which of the specific acoustical elements of a lullaby encourage relaxation, how singing interacts with other activities and environments to induce relaxation, and what inferences infants might make during listening.

The research provides evidence that singing can help infants relax — and in doing so might improve daily life for both child and caregiver.

"While the music in general was relaxing, there was something about the lullabies that was especially relaxing, so in theory there could be ways to optimize the music we provide to infants, to make them more effective," added Bainbridge. "Additionally, it's an interesting area to explore as far as the function of music — is it an adaptation that we evolved to have or a byproduct of language or auditory cognition? Our findings do seem to support the idea that there is actually an evolutionary function of music."

Virtual lab finds the right AI tool for each chemistry problem

Date: March 22, 2021
Source: North Carolina State University
Summary: Having the right tool for the job makes the job a lot easier, less expensive and faster. Chemical engineering researchers have now developed a virtual laboratory that can be used to determine the artificial intelligence tools best suited for addressing various chemical synthesis challenges in flow chemistry systems.

Having the right tool for the job makes the job a lot easier, less expensive and faster. Chemical engineering researchers have now developed a virtual laboratory that can be used to determine the artificial intelligence (AI) tools best suited for addressing various chemical synthesis challenges in flow chemistry systems.

"Autonomous systems have tremendous potential for accelerating chemical R&D and manufacturing, but they are not in widespread use yet," says Milad Abolhasani, corresponding author of a paper on the work and an assistant professor of chemical engineering at North Carolina State University. "These systems face two kinds of challenges: finding or developing the right hardware for reliable, reproducible automated synthesis; and finding or developing the right 'brain,' or AI-guided decision-making algorithm, for efficiently determining the best way of synthesizing the desired material. My team focused on the hardware challenges with our Artificial Chemist project. The work we're publishing now is focused on addressing the autonomous decision-making challenges."

Abolhasani's work stems from his observation that: A) there are a lot of different AI tools available; B) it's not always clear which tool is the best fit for any given material synthesis problem; and C) whichever tool is selected, it will always need to be fine-tuned based on the chemistry problem.

"Recently, there has been increased interest in using off-the-shelf AI programs for modeling and optimization of chemical reactions," Abolhasani says. "But those off-the-shelf AI techniques are not one-size-fits-all — they're not all equally good at solving whatever material synthesis problem you want to address.

"Ultimately, we want to find the best AI model architecture for determining the best material formulation that gives you the target properties you are looking for. Not just identifying the best material, but the best way of producing that material so that it has the best possible combination of characteristics. And the best AI model architecture is going to vary depending on the material and the complexity of the challenge."

So Abolhasani and his collaborators took an AI-driven approach to finding the best AI tool for each material synthesis problem.

"It would be impossible to do the millions of experiments necessary to determine which AI tools do the best job for addressing different kinds of material synthesis problems," Abolhasani says. "So, we wanted a model that simulates a real-world microfluidic experimental platform to effectively run those millions of experiments for us."

The researchers ran 1,000 experiments using their automated Artificial Chemist platform

and used those experimental data points to train the virtual experimental platform.

For the work reported in the new paper, the virtual laboratory simulated more than 600,000 experiments, assessing more than 150 AI-guided decision-making strategies. If those experiments were run in the real world, even using automated systems and microscale volumes of material, the experiments would have taken 7.5 years of continuous robotic operation and 400 liters of reagents. Abolhasani's team did it in about a month.

"We've effectively trained our virtual lab to choose the best AI tools for each material synthesis challenge," Abolhasani says. "And those tools become more efficient every time we use them, helping us resolve increasingly complex challenges in chemistry and chemical engineering. Ultimately, we think that these AI-driven tools will be able to operate quickly enough to adjust operations as needed in real time."

The Double Helix

The Double Helix: A Personal Account of the Discovery of the Structure of DNA is an autobiographical account of the discovery of the double helix structure of DNA written by James D. Watson and published in 1968. It has earned both critical and public praise Watson is a U.S. molecular biologist, geneticist and zoologist, best known as one of the co-discoverers of the structure of DNA in 1953 with Francis Crick.In 1998, the Modern Library placed The Double Helix at number 7 on its list of the 100 best nonfiction books of the 20th century. In 2012, The Double Helix was named as one of the 88 "Books That Shaped America" by the Library of Congress.

"Surely You're Joking, Mr. Feynman!": Adventures of a Curious Character is an edited collection of reminiscences by the Nobel Prize-winning physicist Richard Feynman. The book, released in 1985, covers a variety of instances in Feynman's life. The anecdotes in the book are based on recorded audio conversations that Feynman had with his close friend and drumming partner Leighton. The book has many stories which are light-hearted in tone, such as his fascination with safe-cracking, studying various languages, participating with groups of people who share different interests (such as biology or philosophy), and ventures into art and samba music.

Other stories cover more serious material, including his work on the Manhattan Project (during which his first wife Arline Greenbaum died of tuberculosis) and his critique of the science education system in Brazil. The section "Monster Minds" describes his slightly nervous presentation of his graduate work on the Wheeler–Feynman absorber theory in front of Albert Einstein, Wolfgang Pauli, Henry Norris Russell, John von Neumann, and other major scientists of the time.

Wings of Fire: An Autobiography of A P J Abdul Kalam (1999), former President of India. It was written by Dr. Abdul Kalam and Arun Tiwari. Dr. Kalam examines his early life, effort, hardship, fortitude, luck and chance that eventually led him to lead Indian space research, nuclear and missile programs. Kalam started his career, after graduating from Aerospace engineering at MIT (Chennai), India, at Hindustan Aeronautics Limited and was assigned to build a hovercraft prototype. Later he moved to ISRO and helped establish the Vikram Sarabhai Space Centre and

pioneered the first space launch-vehicle program. During the 1990s and early 2000, Kalam moved to the DRDO to lead the Indian nuclear weapons program, with particular successes in thermonuclear weapons development culminating in the operation Smiling Buddha and an ICBM Agni (missile). Kalam died on 27 July 2015, during a speech at Indian Institute of Management in Shillong, Meghalaya.

Explainer: What are logarithms and exponents?

When COVID-19 hit the United States, the numbers just seemed to explode. First, there were only one or two cases. Then there were 10. Then 100. Then thousands and then hundreds of thousands. Increases like this are hard to understand. But exponents and logarithms can help make sense of those dramatic increases.

Scientists often describe trends that increase very dramatically as being exponential. It means that things don't increase (or decrease) at a steady pace or rate. It means the rate changes at some increasing pace.

An example is the decibel scale, which measures sound pressure level. It is one way to describe the strength of a sound wave. It's not quite the same thing as loudness, in terms of human hearing, but it's close. For every 10 decibel increase, the sound pressure increases 10 times. So a 20 decibel sound has not twice the sound pressure of 10 decibels, but 10 times that level. And the sound pressure level of a 50 decibel noise is 10,000 times greater than a 10-decibel whisper (because you've multiplied 10 x 10 x 10 x 10).

An exponent is a number that tells you how many times to multiply some base number by itself. In that example above, the base is 10. So using exponents, you could say that 50 decibels is 104 times as loud as 10 decibels. Exponents are shown as a superscript — a little number to the upper right of the base number. And that little 4 means you're to multiply 10 times itself four times. Again, it's 10 x 10 x 10 x 10 (or 10,000).

Logarithms are the inverse of exponents. A logarithm (or log) is the mathematical expression used to answer the question: How many times must one "base" number be multiplied by itself to get some other particular number?

For instance, how many times must a base of 10 be multiplied by itself to get 1,000? The answer is 3 (1,000 = 10 × 10 × 10). So the logarithm base 10 of 1,000 is 3. It's written using a subscript (small number) to the lower right of the base number. So the statement would be log10(1,000) = 3.

At first, the idea of a logarithm might seem unfamiliar. But you probably already think logarithmically about numbers. You just don't realize it.

Let's think about how many digits a number has. The number 100 is 10 times as big as the number 10, but it only has one more digit. The number 1,000,000 is 100,000 times as big as 10, but it only has five more digits. The number of digits a number has grows logarithmically. And thinking about numbers also shows why logarithms can be useful for displaying data. Can you imagine if every time you wrote the number 1,000,000 you had to write down a million tally marks? You'd be there all week! But the "place value system" we use allows us to write down numbers in a much more efficient way.

Why describe things as logs and exponents?

Log scales can be useful because some types of human perception are logarithmic. In the case of sound, we perceive a conversation in a noisy room (60 dB) to be just a bit louder than a conversation in a quiet room (50 dB). Yet the sound pressure level of voices in the noisy room might be 10 times higher.

Another reason to use a log scale is that it allows scientists to show data easily. It would be hard to fit the 10 million lines on a sheet of graph paper that would be needed to plot the differences from a quiet whisper (30 decibels) to the sound of a jackhammer (100 decibels). But they'll easily fit on a page using a scale that's logarithmic. It's also an easy way to see and understand big changes such as rates of growth (for a puppy, a tree or a country's economy). Any time you see the phrase "order of magnitude," you're seeing a reference to a logarithm.

Logarithms have many uses in science. pH — the measure of how acidic or basic a solution is — is logarithmic. So is the Richter scale for measuring earthquake strength.

In 2020, the term logarithmic became best known to the public for its use in describing the spread of the new pandemic coronavirus (SARS-CoV-2). As long as each person who got infected spread the virus to no more than one other person, the size of the infection would stay the same or die out. But if the number was more than 1, it would increase "exponentially" — which means that a logarithmic scale could be useful to graph it.

Basic bases

The base number of a logarithm can be almost any number. But there are three bases which are especially common for science and other uses.

1. Binary logarithm: This is a logarithm where the base number is two. Binary logarithms are the basis for the binary numeral system, which allows people to count using only the numbers zero and one. Binary logarithms are important in computer science. They're also used in music theory. A binary logarithm describes the number of octaves between two musical notes.
2. Natural logarithm: A so-called "natural" logarithm — written ln — is used in many areas of math and science. Here the base number is an irrational number referred to as e, or Euler's number. (The mathematician Leonhard Euler did not intend to name it after himself. He was writing a math paper using letters to represent numbers and happened to use e for this number.) That e is about 2.72 (though you can never write it down completely in decimals). The number e has some very special mathematical properties that make it useful in many areas of math and science, including chemistry, economics (the study of wealth) and statistics. Researchers also have used the natural logarithm to define the curve that describes how a dog's age relates to a human one.
3. Common logarithm: This is a logarithm where the base number is 10. This is the logarithm used in measurements for sound, pH, electricity and light.

Explainer: How PCR works

Copy machines are handy in schools and

offices because they can quickly duplicate pages from all types of sources. Similarly, biologists often need to make many, many copies of genetic material. They use a technology called PCR. It's short for polymerase (Puh-LIM-er-ase) chain reaction. Within just a few hours, this process can make a billion or more copies.

The process starts with DNA, or deoxyribonucleic (Dee-OX-ee-ry-boh-nu-KLAY-ik) acid. It's a playbook with instructions that tell each living cell what to do.

To understand how PCR works, it helps to understand the structure of DNA and its building blocks.

Each DNA molecule is shaped like a twisted ladder. Each rung of that ladder is made of two linked chemicals, known as nucleotides. Scientists tend to refer to each nucleotide as A, T, C or G. These letters stand for adenine (AD-uh-neen), thymine (THY-meen), cytosine (CY-toh-zeen) and guanine (GUAH-neen).

One end of each nucleotide holds onto an outside strand — or edge — of the ladder. The other end of the nucleotide will pair up with a nucleotide holding onto the ladder's other outside strand. The nucleotides are picky about who they link up with. All A's, for instance, must pair with T's. C's will pair only with G's. Each letter is therefore the complement of the other in its pair. Cells use this picky pairing pattern to make an exact copy of their DNA when they divide and reproduce.

That pattern also helps biologists copy DNA in the lab. And they might want to copy only part of the DNA in a sample. Scientists can tailor which bit they copy using PCR. Here's how they do it.

Heat, cool and repeat

Step one: Insert DNA into a test tube. Add in short strings of other nucleotides, known as primers. Scientists choose a primer that will pair with — or complement — a specific series of nucleotides at the end of the DNA bit they want to find and copy. For instance, a string of A, T and C will only pair with a T, C and G. Each such series of nucleotides is known as a genetic sequence. Scientists also throw into the mix a few other ingredients, including single nucleotides, the building blocks needed to make more DNA.

Now place the test tube into a machine that heats and cools these test tubes over and over again.

A normal piece of DNA is described as double-stranded. But before it prepares to reproduce itself, DNA will split down the middle of the ladder. Now the rungs separate in half, with each nucleotide remaining with its adjacent strand. This is known as single-stranded DNA.

With PCR technology, after the sample cools down again, the primers seek out and bind to the sequences they complement. Single nucleotides in the mix then pair up with the rest of the open nucleotides along the targeted single strand portion of DNA. In this way, each original bit of target DNA becomes two new, identical ones.

Each time the heating and cooling cycle repeats, it's like pressing "start" on a copy machine. The primers and extra nucleotides duplicate the selected portion of DNA again. PCR's heating and cooling cycles repeat over and over and over.

With each cycle, the number of target DNA pieces doubles. In just a few hours, there can be a billion or more copies.

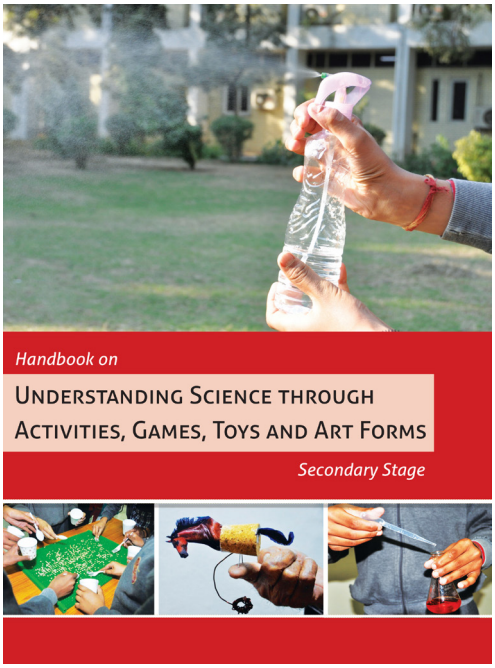
PCR acts like a genetic microphone

Scientists describe this copying as amplifying the DNA. And that's the real value of PCR. Think about walking into a crowded cafeteria. Your friend is sitting somewhere inside. If your friend saw you and said your name, you might not hear it above all the other students talking. But suppose the room had a microphone and sound system. If your friend announced your name over the mike, that voice would drown out all the rest. That's because the sound system would have amplified your friend's voice.

Similarly, after PCR has copied a selected bit of DNA in some sample, those over-represented copies will drown out everything else. The process will have copied the target snippets of DNA so many times that soon they vastly outnumber all of the rest of the genetic material. It's like trying to pick out just the red M&Ms from a big bin. Picking out individual candies would take a really long time. But suppose you could double the red M&Ms over and over. Eventually, nearly every handful would contain just what you wanted.

Scientists use PCR for many types of work. For instance, scientists might want to see whether someone has a certain gene variation, or mutation. That altered gene might signal the person has a higher risk for a certain disease. PCR also can be used to amplify tiny bits of DNA from a crime scene. That lets forensic scientists work with the evidence and match it to other samples, such as DNA from a suspect. Environmental scientists might use PCR to see if any of the DNA taken from a river matches a particular species of fish. And the list goes on.

All in all, PCR is a really handy tool for genetics work. And who knows? Maybe one day you'll find yet another use for this DNA copying machine.



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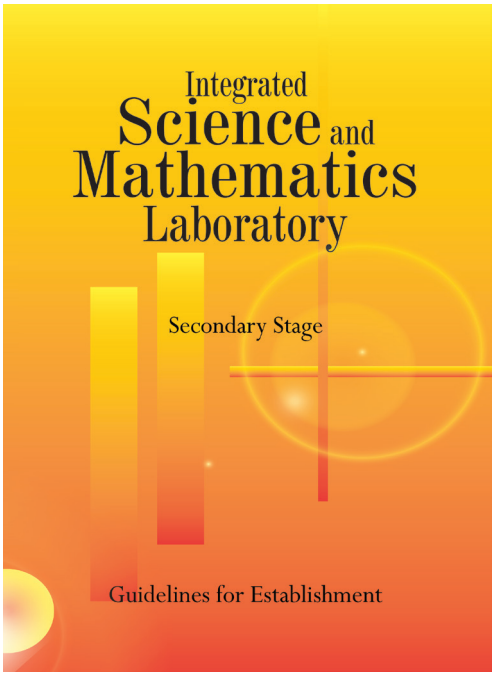

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